"STATISTICAL MODELS IN GROWTH DYNAMICS OF UNDER-5 CHILDREN IN INDIAN STATES"

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For the award of the degree of

Doctor of Philosophy in the Faculty of

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By

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Date: **Signature of the Research Scholar**

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LIST OF ABBREVIATIONS USED (IN ALPHABETICAL ORDER)

Abbreviation	Full Form
AIC	Akaike Information Centre
BIC	Bayesian Information Centre
BMI	Body Mass Index
CNNS	Comprehensive National Nutrition Survey
CDC	Centre for Disease Control
CI	Confidence Interval
EDHS	Ethiopian Demographic and Health Survey
IAP	Indian Academy of Pediatric
IIPS	International Institute for Population Sciences
LL	Lower Limit
LMS	Lambda Mu Sigma
MGRS	Multicenter Growth Reference Study
MUAC	Mid to Upper Arm Circumference
MOHFW	Ministry of Health and Family Welfare
NFHS	National Family Health Survey
NITI	National Institution for Transforming India
NCHS	National Centre for Health Statistics
OR	Odds Ratio

ROC	Receiving Operating Characteristics
RCTs	Randomized Controlled Trials
SC	Synthetic Charts
SE	Standard Error
SD	Standard Deviation
TDHS	Tanzania Demographic and Health Surveys
USAID	United States Agency for International Development
UL	Upper Limit
UNCIEF	United Nations International Children’s Emergency Fund
WHO	World Health Organization
WAZ	Weight for Age Z - Score
WHZ	Weight for Height Z - Score

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ABSTRACT

Background

Malnutrition in India, like some other Developing Countries, is mostly in form of under-nutrition, such as - stunting, wasting and under-weight. Under-nutrition in our country is a leading cause of morbidity and mortality for infants and young children below 5 years of age.

Objectives

This Study was undertaken to model growth dynamics of under-5 Indian children in terms of stunting, wasting, and underweight in relation to their determinants; bring-forth major determinants of their growth and prepare region-specific Growth–Nomograms for use in health planning and research in the country.

Methodology

The Study used Secondary Data on nutrition for under 5 children from country's NFHS – Fourth Round. Two Statistical Software – SPSS and Microsoft Excel were used for data analysis. For analysis purpose, India was suitably divided into 6 geographical Regions. Logistic Regression Model was used to study growth dynamics of under 5 children in terms of stunting, wasting and under-weight. To bring-forth growth determinants, Generalized Linear Model was used. Further, Power Model and Cubic Model were used for preparing Growth Nomograms of height and weight for different birth-weight categories.

Results

The stunting had prevalence rate between 25.9% (Southern Region) and 38.4% (Central Region), under-weight had it between 18.4% (Northern Region) and 37.4% (Eastern Region) and wasting had prevalence rate between 11.3% (Northeast Region) and 22.3% (Western Region). Further, odds of stunting, wasting and underweight were significantly higher for factors, such as - poorest group, uneducated mothers, children with birth-order 4 & above and for under-weight mothers than their counterparts in most of the Regions. In the same way, child age & sex, birth-order, mother's education, respondent's occupation, wealth index and BMI were, by & large, identified as significant determinants of children's height and weight. However, such a situation sometimes, was variable for regions and also for under-nutrition's three conditions. Furthermore, Growth-Nomograms prepared here for both the sexes and for each of the 6 Indian Regions provide Region – Specific Growth References for the country.

Conclusions

Stunting, in our country is most prevalent, followed by under-weight and then wasting. Several socio-demographic factors contribute towards under-nutrition and children's growth. For reducing malnutrition, such factors need to be integrated in the future health programs of the country. Growth-Nomogram prepared here can be used as Region–Specific-Growth References by the health researchers of the country.

Key-words

Birth-weight; Growth-nomograms; Indian regions; Statistical models; Stunting; Under-nutrition; Under-weight; Wasting.

1. INTRODUCTION

Malnutrition, in an individual, is identified by deficiencies, excesses, or imbalances in his/her intake of nutrients and/or energy. It encompasses both - overnutrition and undernutrition, serving as barriers to individuals' attainment of good health[1]. Malnutrition in individuals occurs when they do not receive adequate calories & protein for their growth & maintenance. This deficiency in them may result from various factors, including poor health -preventing effective utilization of consumed food (also called, undernutrition) or an excess of calorie intake (called, overnutrition), as advocated by Das and Gulshan (2017)[2]. Further, the term malnutrition encompasses 3 primary categories of conditions/diseases, given below[3].

- *Undernutrition*: It includes wasting (low weight-for-height), stunting (low height-for-age), and under-weight (low weight-for-age).
- *Micronutrient-related malnutrition*: It includes micronutrient deficiencies (i.e., lack of important vitamins and minerals) or micronutrient excess; and
- *Overweight & obesity and diet-related noncommunicable diseases*. These include heart disease, stroke, diabetes & some cancers.

Malnutrition or growth failure is an awful public health issue. It is a pathological abnormality, caused by imbalanced, inadequate or over-consumption of macro-nutrients that supplies dietary energy and micronutrients that are essential for physical as well as cognitive development[4]. Malnutrition poses a considerable public health challenge for children below the age of five years - hindering both, their cognitive & physical development while also contributing to child morbidity and mortality[5,6]. It is a multifaceted condition, influenced by numerous interrelated factors. These include, but are not limited to, poverty, low parental literacy, inadequate sanitation, insufficient food intake, diarrhea & other infections, sub-optimal feeding practices, family size, low birth intervals, maternal time availability, child-rearing practices and seasonality[7].

1.1 Background

In Underdeveloped as well as Developing Nations, malnutrition continues to pose a severe threat to children's survival, growth, and development. South East Asian and Sub-Saharan countries in Africa are specially affected from the malnutrition. However, in these countries; malnutrition is mostly in the form of undernutrition. Here, particularly for infants and young children under the age of five, undernutrition is a leading cause of morbidity and mortality[8]. It not only poses a significant public health challenge but also serves as a crucial indicator for tracking the nutritional well-being and9also for the survival of children under the age of 5 years in numerous Developing Countries worldwide[9]. Undernutrition is characterized as the result of insufficient food intake (hunger) and recurrent infectious diseases, which include being underweight, too short for one's age, dangerously thin for one's age, and lacking in vitamins & minerals i.e., micronutrient malnutrition[10].

1.1.1 Extent of the Problem

The burden of undernutrition (including stunting, underweight, and wasting) globally among under-5 children is high[11]. Malnutrition significantly influences the global burden of various diseases, with at least 50% of all deaths among children below the age of five years worldwide attributed to undernutrition each year. In 2016, the World Health Organization approximated that there were a minimum of 155 million stunted, 52 million wasted, and 99 million underweight children below the age of 5 years worldwide[12]. WHO's Global Target 2025 is aimed at diminishing malnutrition, focusing on the reduction of stunting, wasting, and low weight. In 2019, a global overview revealed that 38.3 million children (5.6%) were grappling with being overweight, 47 million (6.9%) faced wasting, and a staggering 144 million (21.3%) were affected by stunting[13].

In Africa, more than one-third of children under the age of five (39%) are undernourished, and for Sub-Saharan Africa, this figure rises to 41%. Ethiopia, located in Sub-Saharan Africa, stands out as one of the nations with the highest prevalence of undernutrition. According to the 2018 Worldwide WHO Report, the rates of anthropometric indices—stunting, underweight, and wasting—in children under the age of five years in Ethiopia were 24.7%, 15.1%, and 7.8%, respectively[14]. Bangladesh, Pakistan, and India are the three South Asian nations with the highest prevalence of the condition. According to Pakistan's National Nutrition Study - 2011, 31% of children under the age of five years were underweight, 15% were wasted, and 44% were stunted[12].

India continues to grapple with a significant public health challenge related to undernutrition in children below the age of five years. The 2018 Global Nutrition Report reveals that one-third of the global population of undernourished children resides in India. Undernutrition, characterized by stunting (height for age, z score below 2), underweight (weight for age, z score below 2), and wasting (weight for height, z score below 2), stands as the primary factor behind over 40% of deaths among children under the age of five in India[15]. Among children below the age of five years residing in rural areas of India, prevalence rates of underweight, stunting, and wasting were approximated at 43%, 48%, and 20%, respectively. In contrast, for tribal children, these percentages were notably higher, reaching 55%, 54%, and 28%, respectively[16].

As per India's National Family Health Survey 4[17], 35.7% of children under the age of five were underweight, 38.4% were stunted, and 21% were wasted. These statistics, based on NFHS Data[17] underscore a significant prevalence of undernutrition within this age group[18]. Indeed, there seems to be a positive shift from the previous NFHS Survey (NFHS-3) conducted between the years 2005-2006, particularly in terms of stunting and underweight among children. The updated NFHS-4 Data reflect a comparatively lower prevalence of these nutritional challenges[18]. The prevalence of undernutrition has not decreased as expected from NFHS-1 to NFHS-4. According to the Comprehensive National Nutrition Survey Report (2016–2018), 17% of wasting and 33% of underweight children in India aged 0–4 years have stunted growth[19].

1.1.2 Stunting

Childhood linear growth faltering, commonly known as stunting, stands as a significant global health concern. Stunting carries consequences that extend beyond the short term, impacting health and development throughout an individual's life cycle and even across generations[20]. In 2017, according to a UNICEF Report[21], the predominant indicator of childhood malnutrition was stunting - impacting an estimated 151 million such children worldwide. The Report highlights a lack of progress toward achieving the 2025 World Health Assembly target of a 40% reduction in stunting. Surprisingly, between 2000 and 2017, the number of stunted children in Africa rose from 50.6 million to 58.7 million, indicating an unexpected increase in this critical health issue[22].

Stunting - indicative of chronic undernutrition, prevails as the predominant form of undernutrition among children in Underdeveloped as well as Developing Nations. A projection in 2011 estimated that there were 165 million stunted children in the Underdeveloped Regions. In Africa, when compared to other Regions, there has been a comparatively modest decline in the prevalence of stunting[23]. Regarding the prevalence of stunting across Sub-Saharan Africa, Eastern Africa exhibited a higher rate at 36.7% compared to Western Africa (21.4%), Central Africa (32.5%), and Southern Africa (28.1%)[9]. Stunting is attributed to a diverse range of factors, varying across locations, and encompassing geographical, racial, social, and economic dimensions[24].

According to the National Family Health Survey-4, conducted in 2015–16, in the State of Maharashtra, 34% of children under the age of five were reported to be stunted[25]. According to India's National Family Health Survey -3, conducted in 2006, 48% of Indian children, aged 0 to 59 months were stunted. In Maharashtra - India's second most populous State with a population exceeding 112 million, the challenging nutrition situation among children was affirmed by India's National Family Health Survey-4. The Survey indicated that 38.8% of children, aged 0–23 months in Maharashtra were stunted, and among the stunted children, over one-third (14.7%) were classified as severely stunted[26]. The initial Comprehensive National Nutrition Survey (CNNS) revealed that 35% of children less than 5 years of age were stunted[27].

1.1.3 Wasting

Wasting is one of the symptoms of childhood malnutrition, which can manifest itself in a variety of ways. To quantify wasting, the Mid-to-Upper Arm Circumference (MUAC) or the Weight-for-Height Nutritional Index (WFHNI) can be used. Malnutrition continues to have an impact on the lives of several young children across the world through wasting. Globally, in the year 2017, nearly 50.5 million children below 5 years of age, representing 7.5% of them, experienced wasting - a slight decrease from 7.9% in the year 2012. Among them, 2.4% of under 5 children exhibited severe wasting. These figures suggest modest progress toward the 2025 goal of reducing wasting to 5%[28]. The prevalence of wasting reduced globally from 9% in 1990 to 8% in 2015[5].

The occurrence of wasting commonly fluctuates with the changing seasons, influenced by variations in climate, disease patterns, and the availability of food. Significant inter-State differences in wasting are often apparent, as evidenced by the period between 2005–2006 and 2019–2021, during which 15 out of 29 Indian States experienced an increase in prevalence, while 14 States witnessed a decline[29]. Since the NFHS-3 Survey in 2005–2006, there seems to be an increase in the prevalence of wasting in NFHS-4, rising from 19.8% to 21.0 %[30]. The prevalence of wasting in Uttarakhand was 19.5% as per the 4th round of NFHS[31].

1.1.4 Underweight

When a child becomes either thin or short for his / her age, he/she is considered to be *underweight*. This is considered a significant indicator of health and nutritional status in the population. Even though the percentage of underweight children worldwide has decreased from 25% in 1990 to 15% in 2015, the decline has not been evenly distributed; 90% of underweight children have been from South East Asia and Sub-Saharan Africa. In Tanzania, 2,562 children below the age of 5 were underweight, with 40% of them being under two years of age, according to the 2018 National Nutrition Survey[32].

The prevalence of underweight among children under 60 months of age in Nigeria remains a significant public health concern. Over the past 15 years, there has been only a modest decrease of 8.3%, moving from 24% in 2003 to 22% in 2018[33]. The prevalence of chronic malnutrition and underweight was around 39.9% and 26.6% throughout Africa and South East Asia respectively. Worldwide, 101 million (16%) children under the age of five were reported to be underweight in 2011 – this was a 36% decrease from the projected 159 million in 1990. The frequency of underweight reduced over the previous 16 years, according to Ethiopian Demographic and Health Surveys, conducted in 2000, 2005, 2011, and 2016; the numbers were 41, 33, 29, and 24%, respectively. In West Ethiopia, a Cross-Sectional Study involving children between 0-24 months found that the prevalence of underweight was 15.1% among those under the age of 12 months and 8.9% among those between 0-24 months[34].

In the Indian Sub-continent, as per NFHS – 4, the prevalence of underweight under 5 children in Uttarakhand was 26.6%[31]. In the year 1992 – 93, children in the age group of 0 – 47 months, 49% were underweight[35]. In India, National Nutrition Strategy, unveiled by the NITI Aayog in 2017, had set a targeted goal of annually decreasing the prevalence of underweight in children aged 0–3 by 3.0 % by 2022. Achieving this objective was ambitious, especially considering the substantial progress made over the last decade, with a 7% reduction (from 43% to 36%) in the proportion of underweight children under 5 years old[36].

1.1.5 Statistical Models of Growth Dynamics in Under-5 Children

Studying the physical growth & development of young children is a challenging & complex topic that often considers a variety of genetic, physiological, and socio-economic factors. To develop better preventative measures, our interest sometimes is to understand the factors that drive growth faltering in such children. Further, monitoring of child growth does not occur in a regular manner and instead, we may have to rely on sporadic observations that are subject to substantial measurement errors. Also, there may be a great deal of interest in estimating a child's growth where measurements are sparse, it is important to have some measurement of how much correlation exists between a child's growth measures across different ages.

One of the most perplexing challenges, facing developmental researchers today is the statistical modelling of two or more behaviors as they unfold jointly over time. Although quantitative methodologists have studied these issues for more than half a century, no widely agreed-upon principled strategy exists to empirically analyze developmental processes. Indeed, the plethora of available options makes selecting a specific analytic approach both confusing and overwhelming. For children below 5 years of age, to study their growth and growth trajectories, statistical modelling is a powerful tool. It entails fitting models to physical growth data in order to obtain appropriate growth curves provided by children's anthropometric measurements, such as height and weight, even if these are irregularly spaced. Also, a proper study of the actual contribution of known correlates of a child’s under-nutrition is possible only by applying advanced statistical tools, such as - mathematical models.

Child growth failure was responsible for more than 23% of under-5 mortality, making it the second most common risk factor for child mortality in sub-Saharan Africa. A useful method for examining child growth and growth trajectories is mathematical growth modelling. It entails fitting models to physical growth data (such as weight, length/height, and head circumference) to produce a growth curve that is appropriate and will conveniently summarize the growth information provided by children's weight and height measurements, even from irregularly spaced growth measurements. The Jenss-Bayley model, Reed model, and Gompertz Functions are a few examples of structural and non-structural growth models that can be used to characterize child growth [37].

In Underdeveloped Nations, nearly 30% of preschoolers experience stunted growth as a result of local ecological factors, namely inadequate nutrition and prevailing illnesses. Due to the fast rate of growth and sensitivity to external variables in this age range, it is believed that growth during infancy is particularly significant. In children from Guatemala, food supplements have been found to have the biggest impact on weight and height growth before the age of one and almost no impact after two[38]. A suitable curve will readily summarize the data presented by the observations of a particular child, which is one justification for fitting models to growth data[39].

1.1.6 Growth Nomograms in Under-5 Children

A complex biological process called growth allows an organism to gain mass and size while maturing morphologically and functionally until it takes on the characteristics of the adult stage. Childhood is characterized by growth, which is the basic physiological process[40]. Plotting individual measures, so-called Growth Charts serves as a common way to show the dynamic process of human growth. Growth Charts are frequently used instruments in pediatric treatment[41].

The standard data for height and weight from the National Centre for Health Statistics (NCHS) were suggested nearly three decades ago, by a Panel of Experts assembled by the WHO to determine the nutritional status of children worldwide. The organization that chose the best available reference data did not meet all the criteria that they utilized to make their recommendation. The reference was immediately used for a wide range of applications involving both individuals and populations and was given the name NCHS/WHO Worldwide Growth Reference[42].

Clinicians in Canada and the United States have frequently utilized height and weight Growth Charts for children, prepared by the National Center for Health Statistics (NCHS) as an additional tool to assess children for health and nutritional issues. Since the late 1970s, WHO has advocated the adoption of these Growth Curves on a global scale. They are based on longitudinal data for children under 36 months of age and cross-sectional data for children 2 to 18 years[43]. In normal paediatric practice, measuring a child's height and length is a crucial and commonly acknowledged component for monitoring their growth and development. The Multicenter Growth Reference Study (MGRS), as well as a Growth Reference for School-aged Children and Adolescents, were the basis for new criteria WHO established in 2006/2007 for evaluating the growth and development of children under the age of five years. The Centre for Disease Control (CDC) published Growth Charts for children in the US from birth to 20 years of age in the year 2000[44].

Growth Charts are frequently employed as a crucial tool for determining the population's and each child's specific nutritional status and growth. Since racial/ethnic variety and environmental factors have an impact on human growth across the world, many nations have developed their own growth standards. New criteria for children from birth to five years old were published by the World Health Organization in April 2006. WHO issued a Growth Reference for Children and Adolescents between the ages of 5 and 19 years in September 2007[45]. Both in clinical settings and during public health check-ups, Growth Charts are crucial and widely used to assess children's growth and development. The Lambda-Mu-Sigma (LMS) Approach was used to define growth standards for Japanese children with percentile values based on the results of the national survey conducted in 2000. These Guidelines have been applied widely, mostly in public health assessments. Standard deviation (SD) scores are preferred by Japanese doctors to measure growth in clinical settings since many doctors believe that percentiles are inappropriate for tracking children with severe growth retardation[46].

It is essential in child care to evaluate growth using objective anthropometric measures like weight, length/height, and body mass index (BMI) to determine nutritional status and growth failure. Children's growth patterns fluctuate over time; hence it is advised that References be updated frequently and since India is going through a nutritional transition, it is essential to routinely update Growth References[47].

The Growth Monitoring Guidelines Committee of the Indian Academy of Pediatrics (IAP) created Growth Charts for Indian children from birth to 18 years of age long back. The multicentric data that was then available from affluent Indian children - more than 20 years ago was used for the purpose. This formed the basis for the Growth References, used in these Guidelines. Since the existing IAP Growth Reference Curves are based on data that was obtained more than 20 years ago, they may no longer be appropriate for use, particularly in an economically Developing Nation like India where significant changes in children's nutritional status have been seen[48]. For Indian children, aged 5 to 18 years, Indian Academy of Pediatrics (IAP) announced updated Growth Charts in January 2015 to replace the previous IAP

Charts, and the Government of India and the IAP have adopted these norms for use in under-five Indian children[49].

For older children, population-specific References are frequently used to track children's growth. In a nation like India, these References are typically based on data gathered from children and adolescents who have access to food, nutrition, and a healthy environment[50]. Some nations, like Indonesia, Romania, and Germany, have recently accepted Synthetic Growth Charts as National References because they feel they are more pertinent than the WHO Growth Charts for their own nation. In 2019, Synthetic Growth References for Indian children aged 0 to 18 were also released[51]. For evaluating the nutritional condition of children under the age of five in a Developing Nation like India, WHO Charts are likely to be more aspirational, and Synthetic Growth References are more relevant[52].

1.2 Literature Review

1.2.1 Malnutrition in Under-5 Children

The malnutrition is a worldwide public health problem. The under-nutrition however, is mostly seen in Developing as well as Under Developed Nations. The magnitude of the problem of under-nutrition – in terms of stunting, wasting and under-weight, differs from country to country, often with regional differences within countries.

1.2.2 Global Scenario: Extent of the Problem

Wondimagegn, (2014) reviewed relevant literature, including observational studies and prospective randomized controlled trials (RCTs), evaluating prevalence and causes of stunting in children under the age of five years in Africa. This allowed them to systematically identify, evaluate and synthesize the best available data on the severity and epidemiological causes of stunting among children. Based on this review, the author discovered that the majority of articles claimed stunting to be most prevalent in Africa and that its progress was deemed to be unsatisfactory. The remaining publications under evaluation, pointed out that main cause of stunting was a synergistic combination between poor dietary intake and illnesses[53]. Hagos et al (2017) carried out a community-based cross-sectional survey to determine the number of stunted and severely stunted children between the ages of 0 and 59 months. They examined spatial variation in the prevalence of stunting, using Local Anselin Moran's I, and they looked for possible local pockets (hotspots) of high prevalence. They also used a Bayesian Geo-statistical Model to find out contributing factors of stunting. They revealed statistically significant clusters of high prevalence of stunting (hotspots) in the Eastern part of the district and clusters of low prevalence (cold spots) in the Western part[23].

In 4 localities of River Nile State in North Sudan, a cross–sectional household survey was conducted by Sulaiman et al (2018) in which 1,635 children under the age of 5 years had taken part, using Multistage Clustering Sampling. The prevalence rates of stunting, underweight, and wasting were found to be 42.5%, 32.7%, and 21.0% respectively, among 1,447 children surveyed[8]. Using the PRISMA Guidelines, Abate et al (2020) conducted a Systematic Review & Meta-Analysis of studies that evaluated the prevalence of underweight, wasting, and stunting among HIV- positive children in East Africa. These studies were taken from Pub Med, the Cochrane Library, Google Scholar, and grey literature. Authors, for HIV-positive children in East Africa, found that prevalence rates of underweight, wasting, and stunting were 41.63%, 24.65%, and 49.68%, respectively[10].

Based on weighted sample of 5,64,518 children, aged 0-59 months, taken from the Demographic Health Surveys from the 5 South Asian Countries, using Multiple Logistic Regression Analyses, studies were conducted to identify factors associated with stunting (Wali et al, 2020)[54] and wasting (Wali et al, 2021)[55]. In fact, stunting affects immediate growth & development of children with long term effects. The prevalence of stunting declined from 51.0% in the year 2000 to 35.0% in the year 2017. As regards wasting in these children in 5 South Asian countries, the above Study demonstrated prevalence rate of more than 15% threshold. In fact, child wasting in South Asia has several unique characteristics – high prevalence and incidence of wasting at birth and in early life, prolonged period of wasting experienced by children in first two years of life and higher prevalence of concurrent stunting and wasting. Li et al (2020) used data from Demographic and Health Surveys from 35 LMICs to conduct a cross-sectional study of 2, 99,353 children who were born singletons and were aged 12 to 59 months with non-pregnant mothers. Analysis showed that 38.8% had stunting, 27.5% had underweight and 12.9% had wasting. Authors also studied association of 26 factors with under-nutrition[11].

Similarly, Tesfaw and Dessie (2022) used cross-sectional study-design in their Study, which was based on data from the 2019 Ethiopia Mini Demographic and Health Survey. This included 5,027 children under the age of five years. Amongst the children studied, authors found that 36.0%, 23.3%, and 9.1% were stunted, underweight and wasted respectively[14]. Gebremeskel et al (2022) used Multilevel Ordinal Logistic Regression Analysis to identify factors of wasting among under-5 children in Ethiopia. Authors used data from the 2016 Ethiopia Demographic and Health Survey, which was carried out from January to June 2016 and included a sample of 8,919 children under the age of five years. Authors found that the prevalence of wasting was 10.1% (901), with 8.1% (632) of children under the age of five years, having moderate wasting and 3.0% (269) having severe wasting[28]. Goson et al (2022) used a Multilevel Logistic Regression Analysis to determine the characteristics associated with the prevalence of underweight in children, aged 0-23 months, 24-59 months, and 0-59 months, using the Extracted NGZ Representative Dataset of 33,776 live-births from the Nigeria Demographic and Health Survey between 2008 and 2018. Authors found that 11,313 NGZ children under the age of 60 months were underweight, with children between ages of 24-59 months, recording highest prevalence (34.8%; 95% confidence interval: 33.5-36.2)[33].

1.2.3 Global Scenario: Major Risk Factors of the Under-Nutrition

In four localities of River Nile State in North Sudan (Sulaiman et al, 2018)' involving children under the age of 5 years, showed that age group of 48–60 months had the highest rate of stunting (82.5%). Compared to girls, boys showed worse signs of malnutrition. Geologically speaking, stunting was more common in the Berber Region. Significantly, inadequate immunization, gastroenteritis and respiratory illnesses were linked to the wasting (p = 0.007, 0.013, and 0.008, respectively). Under-nutrition risk variables included, were low socioeconomic status (p = 0.043), lower home cleanliness (p = 0.022), high family size, absence of family spacing and infants weaned abruptly[8]. Akombi et al (2017) studied risk factors for wasting and underweight in children between the ages of 0 and 59 months. In this Study, Multilevel Logistic Regression Analysis was used. As per the Multivariate Analysis, authors found that geopolitical zone (North East, North West, and North Central), perceived birth size (small and average), sex of child (male), place / mode of delivery (home delivery and non-caesarean), and a fever contraction within 2 weeks before the

Survey were factors, most consistently linked to wasting / severe wasting and underweight / severe underweight[5].

Bhowmik and Das (2018) in their paper, demonstrated how to choose the best Logistic Regression Model for stunting by creating and contrasting a number of plausible models, which ultimately aids in determining the factors that cause childhood stunting in Bangladesh. They made use of anthropometric information on children, gathered from the 2014 Bangladesh Demographic and Health Survey. The development of the normal logistic, survey logistic, marginal logistic, random intercept, and logistic regression models was predicated on the assumptions of independence, sampling design, cluster effect, and data hierarchy. Random intercept logistic model is the best suitable for the children under study, according to a variety of model selection criteria identified by the authors. Authors observed that children older than 11 months, short birth intervals, recent child morbidity, lower maternal education, young pregnancies, lower maternal body mass index, poor household wealth, urban residential location, and residence in the Sylhet Division, all increased the risk of stunting[56].

Agho et al (2019) used cross-sectional surveys from the Gicumbi District in Rwanda, Kitgum District in Uganda, and Kilindi District in Tanzania to analyze data for 9,270 children aged 0-59 months. Authors used Generalized Linear Latent and Mixed Models (GLLAMM) with the mlogit link and binomial family that adjusted for clustering and sampling weights in their Study. After controlling for possible confounding variables, authors observed that the odds of a child being stunted were higher in Rwanda's Gicumbi District while the odds of a child being wasted and underweight were higher in Uganda's Kitgum District. Having diarrhoea two weeks before the survey was significantly associated with severe under-nutrition. They found that wealth index (least poor household), increasing child's age, sex of the child (male), and unavailability of water all year were reported to be associated with moderate or severe stunting/wasting and children of women who did not attend monthly child growth monitoring sessions and children who had Acute Respiratory Infection (ARI) symptoms were significantly associated with moderate or severe underweight[9].

In a cross-sectional Study, involving 2, 99, 353 children who were born singletons and aged 12 to 59 months with non-pregnant mothers. Authors assessed the strengths of associations of 26 factors with child stunting, underweight, and wasting. Authors observed that strongest predictor of child stunting in the pooled population was short maternal height, which was followed by low maternal body mass index and a lack of maternal education. Short paternal height was also significantly associated with higher odds of stunting. With a few notable exceptions (for example, absence of maternal education, ranked 18th–20th in 8 countries for child wasting), parental nutritional status and household socioeconomic circumstances were ranked the strongest (1st to 4th) for most countries[11].

Studies on under-nutrition in under 5 children in 5 countries of South Asia- identifying factors associated with stunting (Wali et al, 2020) and wasting (Wali et al, 2021) have demonstrated useful results. These studies have indicated that mother's education and maternal height were the most significant factors, associated with stunting. Children born to mothers with BMI less than 18.5, those born at home, living in India, Nepal and Pakistan, poor dietary diversity, child's age, and gender determined child stunting in South Asian countries. The Study findings indicated that wasting was higher in children, aged 0-23 months than 24-59 months. Poorer and poorest households had higher prevalence of wasting. Mothers' height played an important role in determining wasting in children. Children who had adequate dietary diversity were at lower odds of being wasted but those born through vaginal birth at a Health Centre were at higher odds of being wasted. These studies strongly stressed on need for more research on stunting and wasting in South Asian countries[54,55].

In Ethiopia, in a cross-sectional study, involving 5,027 children under the age of 5 years, Tesfaw and Dessie (2022)[14] found that the estimated odds of stunting among children from households with secondary education or higher were 0.496 (OR = 0.496) times greater than those for children from households with no education. When compared to children from the poorest households, children from the richest households had a lower risk of stunting (OR = 0.485). Children from urban areas had lower odds of being underweight and wasting than those from rural areas, respectively, by 24.9 and 33.7%[14]. Takele et al (2019) used 2016 Ethiopian Demographic and Health Survey data. In order to determine the socioeconomic, demographic, environmental and health-related risk variables for stunted under-five children, they used Generalized Linear mixed Models. Authors found that the age and sex of the child, preceding birth interval, mother's body mass index, household wealth index, mother's education level, breast-feeding period, type of toilet facility, use of internet and source of drinking water were the major determinants of stunting of under-five children in Ethiopia[22].

Mengesha et al (2020) used data from the 2016 Ethiopian Demographic Health Survey (EDHS) to simulate the impact of nutritional and socioeconomic predictors, which consisted of 7909 children, aged 6 to 59 months. Analysis, using

Bivariable and Multivariable Logistic Regression were carried out. They identified that children between the ages of 24 and 59 months had 9.71 times higher risk of stunting than their younger colleagues between the ages of 6 and 24 months. In comparison to children weighing 23.3 kg and up, those weighing less than 9.1 kg had 27.86 % chance of being stunted. Additionally, living in a rural region, being male, and having mothers with heights below 150 cm were connected to stunting[24].

In their research, Hailu et al (2020) used information from the 2016 Ethiopian Demographic and Health Survey, which covered a total of 9,588 children aged 0 - 59 months. Authors explored spatial heterogeneity and identified individual and household level factors related to stunting and severe stunting, using Spatial and Multilevel Logistic Regression Analyses. They discovered that parameters at the individual level were severely stunted in male children, multiple births, older children, and anaemic children. Children from educated but malnourished mothers as well as those of less wealthy mothers, suffered from severe stunting due to variables at the household level[57]. In order to do a secondary analysis on a sample of 4,327 children, aged 0-23 months, Moshi et al (2021) used data from the Tanzania Demographic and Health Survey (TDHS), 2015-2016. The gender, age, birth weight, mothers' BMI, level of education, and type of toilet facility used by the families were among the risk variables for underweight children identified by authors, using Multivariate Analysis. Additionally, they discovered that compared to male children, female children had a significantly reduced chance of being underweight[58].

Data were gathered by Fenta et al (2020) from the Ethiopian Demographic and Health Surveys (EDHS) conducted in 2000, 2005, 2011 & 2016. Authors utilized multivariate decomposition to identify patterns and identified child, mother, and household factors that were associated with underweight. They also used Logistic Regression to identify significant predictors of underweight for each Survey. Authors found that children with mothers under the age of 20 (OR = 5:75, 95% CI = 1.44, 23.1) had a higher likelihood of being underweight than children with mothers over the age of 45 years. Additionally, they discovered that children with mothers who only had primary education or no education (OR = 1:65, 95% CI 1.05, 2.59 and OR = 1:43, 95% CI 1.15, 1.78, respectively) were more likely to be underweight than children with mothers who had higher education[34]. Similarly in Nigeria, in an analysis-based on extract of data on underweight in under 5 children from the Nigeria Demographic and Health Surveys, between 2008 & 2018, authors (Goson et al, 2022) found that children from low or average-income homes, mothers who were taller than average, those who experienced episodes of diarrhoea and those who resided in the Northeast or Northwest were all consistently & substantially associated to the prevalence of underweight[33].

1.2.4 Indian Scenario: Extent of the Problem

A community-based cross-sectional Study on prevalence and determinants on under-nutrition was carried-out in the tribal areas of Maharashtra in India – covering 1,751 children between 1-5 years of age (Meshram et al, 2012a). It showed that overall prevalence of underweight was 64%, of which 29 % were severely underweight. The extent of overall stunting was about 61% with nearly 30 % being severely stunted and about 29 % of children had wasting with nearly 7% having severe wasting[59]. Authors (Meshram et al, 2012b) in their another article on malnutrition in the same tribal area, which consisted of 14,587 under 5 children, showed noteworthy results. They demonstrated that overall prevalence of underweight was 49 %, of which 19 % were severely underweight. The extent of stunting was about 51 % and of them, 24% were severely stunted. Nearly 22 % children had wasting, of which 7% were severe wasted[60].

A review article from India (Sahu et al, 2015) which used data on malnutrition among under 5 children, gathered from Google Search, Medline & some other sources, demonstrated a high prevalence of mal-nutrition in these children, they showed that this prevalence varied widely from area to area, depending upon the method of assessment (39-75% for underweight, 15.4 – 74% for stunting and 10.5 - 42.3% for wasting)[61]. Rajaram et al, (2016) used National Family Health Survey-3 Data, in a sample of 48, 679 under 5 children to study individual and community level child under-nutrition in India. They first calculated prevalence of each measure of malnutrition according to the maternal and household characteristics. They found that 44% of the under 5 children were stunted, 37% were underweight and 18 % were wasted[62]. Similarly, a cross sectional Study, undertaken in Gumla District of Jharkhand (India), involving mostly tribal population, with 1,070 under-5 children (Chatterjee et al, 2016) revealed a very high prevalence of underweight (54.3 %). The multivariate analysis of data further showed that poverty was the single most important predictor of the underweight[63].

In an in-depth analysis of Maharashtra Comprehensive Nutrition Survey, Aguayo et al, (2016) demonstrated poor linear growth and determinants of stunting in under-2 children. They, based on NFHS Data (2006) showed 48% stunting in Indian children between the ages 0-59 years. Their view was - nearly 61 million children were stunted in India and these stunted children were unable to survive, grow and develop to their full potential. Their feeling further was that stunting in India has been declining at the rate of 2.4 % annually[26]. Huey et al (2019) in their Study on under-nutrition in young children (10-18 months old), living in urban slums of Mumbai, found that 31.2 % children had stunting, 25.1% had under-weight, 9.0% had wasting and 76.0% had anaemia[64]. In another Study (Jeyakumar et al, 2019) on under nutrition in children below 2 years of age in urban slums of Pune (Maharashtra), authors, in a sample of 400 children, found prevalence of stunting to be 34.0%, wasting 15.3% and underweight 21.8%[65].

A community based cross-sectional Study on prevalence and determinants of under-nutrition among under 5 children, residing in the urban slums and rural area of Maharashtra (India) was undertaken by Murarkar et al, (2020). The overall prevalence of stunting in the Study was 45.9% and of wasting, 17.1%[66]. Nearly 35.0% children were underweighted. A similar community-based Study (Rehan et al, 2021) was undertaken in urban and rural areas of Rishikesh (Uttarakhand). It found prevalence of stunting to be 43.3, wasting 24.5% and underweight 37.3%[67]. A Study on childhood stunting (Ajmer et al, 2021) compared its prevalence between India and Bihar. As per its result at national level, almost 2 in 5 children (38.0%) were found to be stunted whereas in Bihar, almost half of the children (48%) were stunted. The prevalence of stunting varied significantly by their socio-economic characteristics in both – India & Bihar[68]. A review article on factors contributing to the childhood stunting in Karnataka by Raj et al (2021) showed that the State fared better than many other Indian States on childhood stunting metrics, experiencing a reduction in stunting prevalence (36.2%). There was however, a high coefficient of variation in the prevalence of stunting across Karnataka and that, there were 9 out of 30 districts having stunting prevalence > 40%[69].

Role of seasonality variation in prevalence and trend of childhood wasting in India has been studied by Dwivedi et al (2023) using NFHS Surveys (2005-2021). Authors demonstrated that prevalence rates of wasting in under 5 children, based on NFHS -3, NFHS - 4 & NFHS -5 Data have been 19.8 %, 21.0% and 19.2 % respectively. Thus, prevalence of wasting increased by 1 % between NFHS – 3 to NFHS - 4 while it decreased by 2 % between NFHS - 4 to NFHS –5[29]. A Study, based on scrutiny from NFHS -4 and NFHS -5, carried-out by Das et al (2021) on prevalence and changes in detection of child growth failure amongst under 5 children of West Bengal, illustrated extent of problem of stunting, wasting and underweight in various districts of West Bengal. The prevalence of stunting ranged between 24.2% in Kolkata and 40.5% in Birbhum in NFHS 4 against 25.8% in Purba Medinipur and 44.8% in Uttar Dinajpur in NFHS -5. For wasting, prevalence ranged between 11.3 % in Darjeeling and 34.6% in Puruliya in NFHS-4 against 16.0% in Uttar Dinajpur and 30.3% in Paschim Medinipur in NFHS-5. Similarly, prevalence of the underweight ranged between 18.3% in North 24 Pargana and 58.2 % in Puruliya in NFHS-4 against 32.2% in South 24 Pargana and 46.3% in Puruliya in NFHS-5[4].

1.2.5 Indian Scenario: Major Risk Factors of Under-Nutrition

Meshram et al (2012a) in a community-based cross-sectional Study in Maharashtra's tribal localities that was consisted of 1,751 preschool children, evaluated nutritional status, using revised WHO Growth Standards. Over the two time periods (1999 & 2008), authors discovered that the prevalence of underweight and stunting have decreased significantly ($p < 0.05$). It was observed that gender, age of the child, literacy status, of mother, household wealth index and morbidity were significantly associated with under-nutrition. Using Logistic Regression Analysis, they demonstrated that children of illiterate mothers and those with morbid conditions had a 1.7 times increased chance of being underweight, while children from lower and middle-class households had a 1.4 times increased risk of stunting. Authors further observed that the risk of underweight was 1.38 times higher in boys than girls while risk of stunting was 1.33 times higher in boys in girls. Wasting was significantly associated with gender as well as morbidity[59]. In their another Study on malnutrition from the same area amongst children below 5 years of age, authors (Meshram et al, 2012b) found that various factors, namely – age & gender of the child, literacy status of parents, household wealth index, family size and morbidity were significantly associated with under-nutrition. In the Study, authors emphasized that besides above factors, variables, such as – breast feeding, child feeding practices, hygienic practices, maternal knowledge about feeding and care during illnesses might also affect the nutritional status of these children[60].

Corsi et al (2016) evaluated the simultaneous impact of 15 identified risk factors for child chronic under-nutrition in India. The risk factors, looked at by the authors for their correlation with under-nutrition, were: vitamin A supplementation, immunization, use of iodized salt, household air quality, better sanitary facilities, safe scavenging of stools, improved drinking water, prevalence of infectious disease, initiation of breast feeding, dietary diversity, age at marriage, maternal BMI, height, education, and household wealth. Using Logistic Regression Analysis, authors determined population attributable risks (PAR) and population attributable fractions (PAF), along with age/sex-adjusted and multivariable adjusted effect sizes (odds ratios) for risk factors[35]. A Study (Chatterjee et al, 2016) from Jharkhand (India), carried-out amongst under -5 children, showed that 55.7% of the boys and 54.3% of the girls were underweight, however, Multivariate Analysis did not show any significant difference between the two sexes[63].

Chowdhury et al (2016) used Multilevel Logistic Regression Models with a random intercept at both the household and community levels. They found that age, sex, mother's body mass index, mother's educational status, father's educational status, place of residence, socio-economic status, community status, religion, region of residence, and food security were significant factors of child malnutrition. Malnutrition was more likely to occur in kids with lower socioeconomic and community levels. There was a higher chance of malnutrition in children from households that were food insecure[70]. For stunting, in an in-depth analysis of Maharashtra Comprehensive Nutrition Survey, Investigators (Aguayo et al 2016), based on their Bivariate and Multivariate Regression Analysis, found that prevalence of stunting was 4-fold higher amongst 18-23 months old than 0-5 months old. There was significant general difference in linear growth and stunting. Poor linear growth & stunting were significantly less prevalent amongst children in urban areas than in rural. Despite significant progress in reducing child under-nutrition over past years, Maharashtra failed to achieve their growth & development potential, as demonstrated by the results of their Study[26].

Das and Gulshan (2017) used height-for-age, weight-for-height, and weight-for-age measurements to assess the severity of malnutrition among infants under 5 in Bangladesh. For the three indicators, Logistic Regression Models were fitted after the relationship between the chosen factors and nutritional condition was evaluated. They found that children of age 0 to 6 months had lowest prevalence of stunting or underweight, and children of age18 to 23 months had higher prevalence (stunting

48% and underweight 37%) whereas wasting was higher between 0 to 6 months. Odd of being stunted was 30% to 50% higher in the Sylhet Division as compared to other Divisions[2]. In their study, Khan et al (2019) used Uni & Multivariate Binary Logistic Regressions to look at the relationship between three proxy measures of child nutritional status and selected maternal-socio-demographic and child level variables (such as - sex, age, size at birth, antenatal clinic visits, recent diarrheal incidence, and breastfeeding status). About 44.4% of children under the age of five were discovered to be stunted, while 29.4% were underweight, and 10.7% were wasted. They found that children whose mothers lived in rural areas, were aged ≥18 years at marriage, and had visited an antenatal clinic more than 3 times during pregnancy were less likely to be stunted. Mother's low educational level, short stature, child's small size at birth and mother's BMI were significantly associated with child's underweight status. Children whose mothers had no education were more likely to be wasted[12].

Akhade et al (2019) conducted a community-based cross-sectional study in which they selected 10 slums randomly. The under 5 children and their mothers from the urban slums were examined and interviewed. They discovered that underweight children were highly correlated with family size, breastfeeding initiation, maternal education, overweight mothers, and maternal nutritional intake. Additionally, they also found that stunted children showed strong association with increasing age of child, birth weight, and not seeking medical opinion whereas primary immunization, maternal education, employed mothers, and underweight mothers were associated with wasting in children[71]. Similarly, in the Vikramgad Block of the Palghar District, Ghosh and Varerkar (2019) evaluated the severity of under-nutrition among 375 tribal children under the age of six, as well as their dietary habits and food practices during April-June 2017. For each of the 375 kids, they measured weight and height. using the

WHO Child Growth Standards, 2006. Their nutritional condition was evaluated. In addition, they used Multivariate Logistic Regression Models to understand how predictor variables independently affected stunting, wasting, and the underweight[25].

Kim et al (2019) used Logistic Regression Models to analyze each correlate initially independently in age and sex-adjusted models, and then together in a mutually adjusted model. Authors found that the strongest correlates for stunting were short maternal stature, lack of maternal education, low maternal BMI, poor household wealth and poor household air quality. They also found weaker associations for other correlates, including dietary diversity, vitamin A supplementation and breastfeeding initiation[36]. Further, a Study in Karnataka by Raj et al (2021) showed that multiple factors often play an important role in determining stunting. In the State of Karnataka, risk factors of childhood stunting were prominently climate, nutrition, infectious diseases, and congenital disorders. The complementary analysis further showed that cultural differences in feeding practices – interacting with epigenetic mechanisms, maternal health & infections, may influence risk differently, depending on the household context[69].

Jeyakumar et al (2019) in children below 2 years of age from Pune, using Regression Analysis, studied association of 5 factors with under-nutrition. Low birth weight, not feeding colostrum, partial immunization and lower maternal education were found to be significantly associated with under-nutrition: stunting, wasting & under-weight. Multinomial Regression Analysis revealed that children above 7 months of age, were at risk of stunting. Fetal growth restriction and poor sanitation were also identified as leading risk factors of for stunting. The results of this Study, highlighted the need for improving maternal nutrition to prevent wasting in first 6 months and to identify innotive strategies to educate and improve knowledge of mothers on importance of infants & young children's feeding practices and prevention of low birth-weight[65]. Another Study, undertaken, to describe the prevalence of under-nutrition in a vulnerable population, considering 10-18 months old children in urban slum of Mumbai (Huey et al, 2019) showed results on the correlates of the under-nutrition. They found that prevalence of stunting, underweight and anaemia among young children of the urban slums in their Study were higher and that of wasting was lower than Mumbai's urban population. Authors found that age of the child was not a significant correlate of under-nutrition. Correlates of under-nutrition were different in males and females. However, maternal factors – height, education, and age were found to be the correlates of the child under-nutrition[64].

A Study in slums & rural area of Maharashtra (Murarkar et al 2020) exhibited significantly more prevalence of stunting, wasting & underweight in urban slums than rural areas. In rural area, factors, viz.- exclusive breast feeding and acute diarrhoea were associated with wasting. Children with birth order 2 or less were associated with stunting and exclusive breast feeding and low maternal education were associated with underweight. As against this in urban slums, exclusive breast feeding was found to be associated with wasting and the two factors - sex of the child and type of family, were with stunting and the poor income of the families was associated with the underweight[66]. Further, a Study by Ajmer et al (2021) on stunting in Bihar and India demonstrated that at India level, child was strongly linked to the probability of being stunted by increasing age. Children whose mothers were less educated were more likely to be stunted than their counterparts. Similarly, if the child's mother was underweight, they were more likely to be stunted. In both India & Bihar, significantly higher odds of stunting were found among children whose mothers were less than 19 years of age, at the time of child birth, had no education, were underweight, had no ante-natal care, visited during pregnancy, belonged to the scheduled caste & tribe groups, followed Islam religion, and belonged to the poor socio-economic status than their counter parts[68].

In a Study on prevalence and change in the growth failure phenomenon amongst under 5 children of West Bengal, Das et al (2021) showed significant association of low or very less parental education, poor family living condition, parental unemployment, less attention in ante-natal & post-natal care, mothers' under nutrition condition, poor maternal & child dietary diversity and poor immunization coverage with child growth failure[4]. Another Study from Rishikesh (Uttarakhand) by Rehan et al (2021) undertaken in urban and rural populations, found prevalence of stunting, wasting & underweight to be considerably higher in urban areas than in their rural counterparts. This Study further showed that socio-economic factors, like religion, caste, parental education, father's occupation, and family size emerged as significant predictors of under nutrition[67]. In the similar way, Dwivedi et al (2023) in their analysis - based on NFHS Data for 3 Rounds (3rd Round to 5th Round) showed that seasonality significantly influenced prevalence of wasting. Compared to January, odds of wasting were significantly higher in summer and monsoon seasons, especially in the month of August for all the 3 Rounds – clearly indicating the effect of season on the prevalence of wasting in under 5 children of the country[29].

As part of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) – 2017, India State-Level Disease Burden Initiative Malnutrition Collaborators (2019) examined the disease – burden, attributable to child and maternal malnutrition as well as trends in the malnutrition indicators from 1990 to 2017 in every State of

India[72]. In four Rounds of nationwide Surveys (Rounds 1 through Round 4), Khadilkar et al (2021b) evaluated the changes in the nutritional status of Indian children under the age of five. Authors examined data from four Rounds of the National Family Health Survey (1992–2016). They discovered that during the course of four NFHS cycles (from 1992 to 2016), there was a higher decrease in stunting (from 54% to 38%, $p < 0.05$) than in underweight (from 44% to 34%, $p< 0.05$) and wasting (from 19% to 20%, $p > 0.1$) status[73].

1.2.6 Statistical Model for Growth Dynamics in Under-5 Children

Statistical modelling is the process of applying statistical methods to a data set. The modelling is the powerful approach to study child growth. A statistical model is a mathematical representation of the observed data. To study child growth and growth trajectories, statistical modelling is a powerful and useful tool. To study growth dynamics of children, statistical models are fitted to the physical growth data in order to obtain appropriate growth curves, provided by children's anthropometric measurements, such as - height and weight. Statistical models provide smooth curves of status and velocity, even from irregularly spaced measurements. Further, as India is going through nutritional transition, it is hard to keep its growth figures up-to-date. Children's growth pattern in our country, have been influenced by country's rapid economic and social transformations. Statistical models help in obtaining estimated growth curves, considering various anthropometric measurements, such as – length / height and weight. Several researchers have brought-forth variety of statistical models for studying different aspects of physical growth and applied them to study growth dynamics of under -5 children. Some of such applications are given below.

Simondon et al (1992) identified the best model in terms of goodness of fit and parameter estimate distribution. Infancy component of the Karlberg Model, the Count Model, and the Kouchi Model, which are all 3-parameter models, were tested together with the four- and five-parameter versions of the Reed Model. Closest fits were obtained, using the Reed Model, followed by the Karlberg Model, while the Count and Kouchi Models provided poor fits. Examination of mean residuals by age showed systematic bias in neonatal weight estimation with the three-parameter models[38]. Similarly, Ward et al (2001) showed how simple it was to employ Preece and Baine's technique I, by producing smoothened development curves for both - height and weight. Using data from the NCHS Growth Curve, authors created smoothened curves and compared them to those created, using the Least Squares-Cubic-Spline Approach. It was determined that the Method I Curve Fitting Procedure by Preece and Baine, fitted centile growth curves for height and weight in 2-18 year old boys and girls and, if not better than, then the Least-Squares-Cubic-Spline Method was used to develop the 1979 NCHS Growth Curves. This was based on the lower sum of squares and better fit of the shape, as indicated on residual examination[43].

López-Siguero et al (2008) determined the final adult height as well as the Reference Criteria for weight, height, and BMI for the paediatric population of Andalusia from 3 to 18 years of age for both the genders. The Cole's LMS Approach was used by the authors to adjust the Reference Curves, and Royston's tests were used to evaluate how well the modification was done. The obtained final models also underwent a sensitivity analysis. Only three girls and two boys out of the first sample (or 0.07%), declined to take part in the Study. In addition, 327 students (or 4.5% of the total sample) were not present. For both genders, they provided the mean and standard deviation for height, weight, and BMI at 0.5-year intervals from 3 to 23 years of age. Percentiles for height, weight (percentiles 3, 5, 10, 25, 50, 75, 90, 95, and 97), and BMI (percentiles 3, 5, 50, 85, 95, and 97) were shown for both the sexes after adjustment with the various models[40].

In their Study, Ahmadi et al (2020) reported various growth characteristics and chose a Growth Model that best described the individual growth trajectories of children aged 0-6 years. In their work, authors used longitudinal weight and height growth data for boys and girls to examine the goodness-of-fit of three Structural Development Models (Jenss-Bayley Model, Reed Model, and a newly modified version of the Gompertz Growth Model). Goodness-of-fit of the models was assessed using residual distribution over age and compared with the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). According to authors, the Jenss-Bayley Model offered the best-fit for height and weight in both boys and girls. While the mean weight growth curve for girls, following neonatal life was slightly lower than the curve for boys, the mean height growth trajectories of boys and girls were identical in shape and direction[37]. Further, Khadilkar et al (2021a) used data from 4th National Family Health Survey for assessing nutritional status, using the WHO Charts & SC. Z- Scores were calculated for length/height, weight, and weight-for- height (WAZ). Children were classified into degrees of malnutrition, using appropriate cut-offs. Authors found that stunting, wasting, and underweight were significantly higher using WHO Charts. The prevalence of stunting (height for age) and wasting (WHZ) changed from high to medium and critical to poor when the Reference changed from WHO to SC. All Z- Scores showed an improving trend with increasing wealth index. On SC, almost all WHZ (wasting) from the richest to poorer were >-0.5 (clinically significant), whereas on WHO Charts, all wealth classes had WHZ <-0.5[52].

Reference curves and normal values are often required in Medicine & Health. These curves and values are used for the evaluation of overall nutritional status of population of children in different settings. Payande et al (2013) undertook a cross sectional Study on measurement of weights of 70,737 children, aged 0-5 years to construct growth curves and normal values of children, living in North-East Province of Iran. They used Non-parametric Quantile Regression Method, obtained by local constant Kernel Estimation of conditional quantile curves, using curves and normal values. They brought-forth References curves of weight for boys and girls separately with Non-Parametric Quantile Regression Method and compared them with Semi-Parametric LMS Method Curves and WHO Growth Curves. They concluded that Quantile Regression Method is a useful method determining for determining Reference Growth Curves and Reference Values for the age dependent variable of medical measurements[74]. Similarly, Berkey (1982) compared two models for growth in length and weight during early childhood for goodness of fit and other qualities. The one model was linear in parameter while another model was non – linear. Both the models were applied to the data for length and weight of children in a large sample. The results have been used to study issues, such as – reliability, efficiency, precision and overall as well as age specific goodness of fit of the models[39].

1.2.7 Growth Nomograms in Under-5 Children

A *nomogram* (or *nomograph*) is a diagram that is used as a tool for visual calculation. It consists of a graduated scale, precisely placed and sized, in the diagram. Each scale represents a variable to solve an equation. Growth nomograms (sometimes, also called growth charts) are mainly of two types – Growth Standards and Growth References. *Growth Standards* define how a population of children should grow, given the optimal nutrition and optimal health. The *Growth References*, on the other hand, are prepared from a population which is thought to be growing in the best possible state of nutrition and health in the given community. They represent how the children are growing rather than how they should be growing (Khadilkar and Khadilkar, 2011)[47]. The advantage of Growth Standard, like the WHO Standard (2006) is that children from various countries and races can be compared against a single Standard and thus, assessment becomes more objective and quite easy to compare. The advantage of the Growth Reference is that they are true representative of the children's existing growth pattern and allow us to study secular trend of anthropometric measurements, such as - height and weight etc. In fact, assessment of growth by objective anthropometric measurements is crucial in child care. The growth nomograms have been frequently used for different purposes in India and abroad. Some of such studies are given here under.

WHO Multi-Centre Growth Reference Study Group (2006) investigated the procedures used to create Growth Charts, based on the WHO Child Growth Standards, which are based on length/height, weight, and age etc. They generate curves, using the Box-Cox Power Exponential (BCPE) Approach, using cubic splines for curve smoothing. They discovered that Age-appropriate Length/Height Standards were created by fitting a special model that captured the 0.7cm average gap between these two measurements. Smoothed percentile curves and empirical percentiles had excellent, bias-free agreement. For weight-for-age, length/height-for-age, weight-for-length/height (45 to 110 cm and 65 to 120 cm, respectively), and body mass index-for-age, percentiles and z-score curves for boys and girls aged 0-60 months were created[42]. Further, Khadilkar et al (2009) conducted cross-sectional study which produced contemporary growth curves for Indian children from 5-18 years for height, weight and BMI. Compared to the 1989 data, median height at 18 years was 0.6 cm greater for boys but unchanged for girls, while the 97th height percentile had increased by 1.7 cm for boys and 2 cm for girls. Boys and girls were found to be heavier and taller at almost all ages. The Study also showed that boys and girls were taller at younger ages[51].

Hermanussen et al (2012) transformed (harmonized), 'presently in use charts' into a single universal interchangeable LMS format, for each European country. Authors harmonized nine currently used National European Growth References from Belgium (2009), France (1979), Poland (2001), Sweden (2002), Switzerland (1989), UK (1990), Italy (2006) and Germany (1979 & 1997) and compared with the International WHO Child Growth Standards and WHO Growth Reference Data for 5–19 years. It is possible to synchronize European Growth Charts. The strategy seems to be effective because WHO References inaccurately represent height and body mass index (BMI). When compared to the WHO Reference, European Height References showed warping. The other Europeans seem excessively tall, while the French seem too short. Additionally, the WHO References do not accurately depict the BMI[41].

Khadilkar and Khadilkar (2011) looked at Growth Standards and related literature in order to evaluate the physical development of Indian youngsters for clinical and academic purposes. They described basics of Growth Charts and importance of anthropometric measurements. Additionally, they discussed Indian Growth Reference Curves, based on data gathered by Agrawal & others. and adopted by the Indian Academy of Paediatrics, World Health Organisation Growth Standards for children under the age of five (2006), and current Indian Growth References, published on ostensibly healthy wealthy Indian children (data gathered in 2007-08).

WHO Growth Standards (for children < 5 years) and current Cross Sectional Reference Percentile Curves (for children from 5-18 years) are accessible for clinical use and for research purposes in the assessment of height, weight, and BMI. It is also possible to examine the physical development of modern Indian youngsters, using BMI percentiles (adjusted for the Asian adult BMI with equivalent cut-offs)[47].

Rosario et al (2011) presented height-for-age percentiles that are common for infants, kids, and teenagers in Germany and contrasted them with older German Height References by Kromeyer-Hauschild (KH), which are based on heterogeneous pooled data, with global Growth Charts from the Centre for Disease Control (CDC), as well as with the Growth Standards and the Growth References of the World Health Organisation. Using Cole's LMS Approach, they produced Height Reference Curves. Additionally, the height values from KiGGS were converted to SD-Scores, using the KH, WHO, and CDC References, allowing comparison with different reference systems. They discovered that the height-for-age percentiles in KiGGS rise until the end of the observed age range (17.98 years) for boys and until the age of 16 for girls. Generally speaking, boys are taller than girls, with the exception of children aged 10.5 to 13.0 years. Before puberty, the height gap between boys and girls is barely noticeable and widens to 13 cm at age 17.98. The percentiles for KiGGS and KH just slightly diverge[44].

Further, based on data of 69,760 urban infants and pre-school children under 7 years and 24,542 urban school children, aged 6–20 years from two cross-sectional national surveys, Zong and Li (2013) constructed China References, including weight, length/height, head circumference, weight-for-length/height, and Body Mass Index (BMI), aged 0–18 years. To smoothen the growth curves, Cole's LMS Approach was used. The empirical standard deviation (SD) curves for each indicator between China and WHO were found to show varying disparities through-out nearly for all age groups. The genders, final heights, and boundary centile - curves showed the most obvious variances. At age 6 to 10 years old, Chinese boys were found to be noticeably heavier than WHO boys. For boys under the age of 15 and for girls under the age of 13, the height was taller than that of the WHO, although it was much shorter for those who were over 15 years and over 13 years[45].

Khadilkar et al (2015a) created revised IAP Growth Charts for 5–18-year-old Indian children, based on compiled national data from published research, conducted on seemingly healthy children and adolescents in the last 10 years. Committee contacted 13 Study Groups; total number of children in the age group of 5 to 18 years were 87,022 (with 54,086 boys). Data from fourteen cities (Agartala, Ahmadabad, Chandigarh, Chennai, Delhi, Hyderabad, Kochi, Kolkata, Madurai, Mumbai, Mysore, Pune, Raipur, and Surat) in India were collated. Data of children with weight for height Z scores >2 SD were removed from analyses. Data on 33,148 children (18,170 boys, 14978 girls) were used to construct Growth Charts, using Cole's LMS method[48].

Khadilkar and Khadilkar (2015b) constructed Growth Charts from a total of 87,022 middle and upper socioeconomic class children (54,086 boys and 32,936 girls) from all five zones of India. Data from middle and upper socioeconomic class children were likely to have higher prevalence of overweight and obesity and hence, Growth Charts produced on such populations were likely to "normalize" obesity. The World Health Organization's technique was utilised to create weight charts in order to exclude such harmful weights from the data. Thus, the new IAP weight charts were much lower than the recently published studies on affluent Indian children. Since Indians are at a higher risk of obesity - related cardio-metabolic complications at lower Body Mass Index (BMI), BMI Charts - adjusted for 23, and 27 adult equivalent cut-offs as per International Obesity Task Force Guidelines, were constructed[49].

For Japanese children, Isojima et al (2016) re-analyzed previously published Growth Standard Charts with percentile values and created Growth Standards with mean and SD values that could be used for both clinical practices and public health assessments. In order to create the Growth Charts, authors utilised the LMS Approach, presuming that the data could be transformed into a normal distribution by using a suitable power transformation (L). The distribution was then summarized by the median (M) and coefficient of variance (S). Polynomial functions with many knots, which were chosen after carefully examining the three curves (L, M and S), were used to fit and smoothen them. Growth Charts with mean and SD values were created using these smoothened L, M, and S data for height and weight[46].

Khadilkar et al (2019) compared Growth References, created from continuous anthropometric data, using LMS Method versus those created synthetically from anthropometric means at key ages. De- identified data on 46,421 children (with 26,037 boys) from 0-18 years of age from several multi-centric studies, conducted by the authors' group (between 2007 to 2017) were included whereas Growth References were constructed, using the LMS Method. There was no difference in the medians for height, weight and BMI between the References created by the two methods. The extreme percentile values for height were similar ($P < 0.05$). However, the spread of values for weight and BMI was narrower in the Synthetic References[50].

1.3 Justification of the Study

Despite malnutrition being the major health problem in India, studies on the growth dynamics of under–5 children, using advanced biostatistical methods have been lacking and so, neither the better estimates of measurements of under-nutrition, such as - stunting, wasting, underweight, and overweight of Indian children are available nor are precise contributions of major risks factors of malnutrition known. Appropriate Nomograms for growth measurements of our children are also not available by specified geographical regions. The present study, using appropriate statistical models, besides prevalence rates of under-nutrition in the different geographical regions of India, identifies its major contributory factors and brings forth better estimates of growth measurements and also nomograms for the height and weight of under-5 children in the country. This Study is expected to benefit healthcare planners, and health researchers on children's growth & development and to the mothers of under-5 children in the country for a better holistic future.

1.3.1 Objectives of the Study

Objectives of the study are:

a) To model growth dynamics of under-5 Indian children in terms of stunting, wasting, and underweight in relation to their determinants.
b) To study major determinants of growth of under-5 children in India.
c) To prepare region-specific Growth–nomograms for use in health planning and research.

2. MATERIAL AND METHODS

2.1 Source(s) of Data

National Family Health Study (NFHS) is an extensive, multi-round survey that was carried out on a representative sample of Indian families. The International Institute for Population Sciences (IIPS) of the country has been recognized as the Nodal Agency in Charge for coordinating and providing technical direction to the NFHS, on behalf of the Ministry of Health and Family Welfare (MOHFW), Government of India. NFHS received funding from the United States Agency for International Development (USAID) and additional assistance from the United Nations Children's Fund (UNICEF). For the Survey's implementation, IIPS worked with several Field Organizations (FO). Since the initial Survey in 1992–1993, five rounds of the NFHS have been conducted. These five rounds of the surveys are as follows:

- In 1992–1993, First National Family Health Survey (NFHS–1) was carried out. It was an important component of the Project to strengthen the survey research capabilities of the Population Research Centres (PRCs) in India.
- The Second National Family Health Survey (NFHS-2), carried out in 1998–1999, was a crucial step for further strengthening the database for the Reproductive and Child Health Approach that India embraced following the International Conference on Population and Development (ICPD) in Cairo.
- The 2005-06 National Family Health Survey (NFHS-3) was the Third Round in a series of National Surveys.

- The Fourth National Family Health Survey (NFHS-4) in the series, conducted in 2015–16, offered data on India's population, health, and nutrition for each State and Union Territory.
- The NFHS-5, which is the fifth edition in the National Family Health Survey series conducted in 2019-21, offers comprehensive data on population, health, and nutrition across India. It covers every state, union territory (UT), and 707 districts as of March 31, 2017.

All five NFHS Surveys have been conducted under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. The data of the National Family Health Survey – 5 were neither published nor ready to use when the present work was initiated. As such National Family Health Survey-4 (NFHS-4) data have been used to address the objectives of the present study. The data usage details are given in Table 2.1.1. The 2015–16 National Family Health Survey's main goal was to offer crucial information on health and family welfare as well as information on newly emerging challenges in these areas. Through a variety of biomarker tests and measurements, the clinical, anthropometric, and biochemical (CAB) components of NFHS-4 aimed to deliver critical estimates of the prevalence of undernutrition, anaemia, hypertension, HIV, and high blood sugar levels.

2.1.1: Data Used for Addressing Study Objectives

Details of data used for addressing various objectives of the present study are given below:

Objectives	**Data**
To model growth dynamics of under-5 Indian children in terms of under-weight, stunting & wasting in relation to their birth weight.	NFHS - 4
To study major determinants of growth of under-5 children in India.	
To prepare Region-Specific Growth – Nomograms for their use in health planning and research.	

NFHS-4 sample is a stratified two-stage sample. To choose Primary Sampling Units (PSUs), the 2011 Census served as the sampling frame. PSUs were villages in rural areas and Census Enumeration Blocks (CEBs) in urban areas. Using a Probability Proportionate to Size (PPS) method, communities within each rural stratum were chosen from the sample frame. In each stratum, six approximately equal substrata were created by crossing three substrata, each creation is based on the estimated number of households in each village, with two substrata, each created based on the percentage of the population belonging to scheduled castes and scheduled tribes. The Office of the Registrar General and Census Commissioner, New Delhi, provided CEB data for urban regions. The percentage of the SC/ST population in each CEB was sorted out, and PPS Sampling was used to choose a sample of CEBs.

NFHS-4 Survey provides demographics and health outcome measures for 640 districts, covering 29 states and 7 Union Territories (UTs) as per the 2011 Indian Census Classification Sampling Frame. It is a large & thorough Survey of the country, including data of children aged 0 – 59 months along – with their several demographic & socio-economic characteristics and anthropometric measurements, such as – birth-weight, their current weight & height/length. NFHS-4 covered 699,686 women of age 15 - 49 years and 112,122 men of age 15-54 years. For the present study, we used a kid's file of NFHS-4 covering 2,59,627 children, to study the growth dynamics of under 5 children in the Indian Region.

2.1.2: India's Six Geographical Regions

As per NFHS–4, we have divided India into 6 Geographical Regions, such as Central Region, Eastern Region, Northern Region, Northeast Region, Western Region, and Southern Region.

The total number (sample) of under-5 children region-wise (as per NFHS-4 data) is described as follows:

Central Region

- Out of a total 2,59,627 children under the age of 5 years, a sample of 75,645 children (39,527 boys and 36,118 girls) belonged to the Central Region.
- It consists of 3 States – Chhattisgarh, Madhya Pradesh & Uttar Pradesh.

Eastern Region

- A total of 2,59,627 under 5 children were studied in the Survey and out of these, 54,075 children (28,013 boys and 26,062 girls) belonged to the Eastern Region.
- It consists of 4 States - Bihar, Jharkhand, Odisha & West Bengal.

Northern Region

- Out of a total 2,59,627 children under the age of 5 years, a sample of 48,703 children (25,762 boys and 22,941 girls) belonged to the Northern Region.
- It consists of 6 States & 2 UTs: - Chandigarh (UT), Delhi (UT), Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttarakhand.

Northeast Region

- Out of 2,59,627 children under the age of 5 years, a sample of 37,167 children (19,050 boys and 18,117 girls) belonged to the Northeast Region.
- It consists of 8 States: - Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura.

Western Region

- Out of a total 2,59,627 children under the age of 5 years, a sample of 18,276 children (9,510 boys and 8,766 girls) belonged to the Western Region.
- It consists of 3 States & 2 UTs: - Dadra & Nagar Haveli (UT), Daman & Diu (UT), Goa, Gujarat, Maharashtra.

Southern Region

- Out of a total 2,59,627 children under the age of 5 years, a sample of 25,761 children (13,240 boys and 12,521 girls) belonged to the Western Region.
- It consists of 5 States & 3 UTs: - Andaman & Nicobar Island (UT), Andhra Pradesh, Karnataka, Kerala, Lakshadweep (UT), Puducherry (UT), Tamil Naidu & Telangana.

2.1.3 Definitions of Stunting, Wasting & Underweight

Undernutrition has been studied in terms of stunting, wasting, and underweight. These have been defined as under:

Stunting (Height-for-Age):

- Height-for-age is a measure of linear growth retardation and cumulative growth deficits.
- Children whose height-for-age Z-score is below minus two standard deviations (- 2 SD) from the median of the Reference Population are considered short for their age (stunted), or chronically undernourished.

Wasting (Weight-for-Height):

- The weight-for-height index measures body mass in relation to body height or length and describes current nutritional status.
- Children whose Z-score is below minus two standard deviations (- 2 SD) from the median of the Reference Population are considered thin (wasted), or acutely undernourished.

Underweight (Weight-for-Age):

- Weight-for-age is a composite index of height-for-age and weight-for-height. It takes into account both acute and chronic undernutrition.
- Children whose weight-for-age Z-score is below minus two standard deviations (- 2 SD) from the median of the Reference Population are classified as underweight.

2.2 Major Determinants of Growth in Under-5 Children

NFHS-4 data were downloaded from the DHS website. The data files were available in 4 different structures in the DHS Data Distribution System, i.e., Stata Dataset (.dta), Flat ASCII Data (.dat), SAS Dataset (.sas7bdat), and SPSS Dataset (.sav). Out of these data file structures, only the SPSS data file (i.e., Kid's file) was used in the present Study. The name of the data used for our Study was IAKR74SV.ZIP of NFHS – 4.

The limited variables were extracted from the Kid's file of the SPSS Data to address all objectives, i.e., to study growth dynamics and major determinants of under 5 Indian children as well as to prepare region-specific growth–-nomograms. The details of the variables are given in Table 2.2.1.

Table 2.2.1: Details of variables used in the objectives 1st, 2nd, and 3rd.

Description	Name of Variables	Data Sources
Child Age (Months)	HW1 (< 12 = 0, 12 – 23 = 1, 24 – 35 = 2, 36 – 47 = 3, 48 – 59 = 4)	
Child Sex	B4 (Male = 1, Female = 2)	
Wealth Index	V190 (Poorest = 1, Poorer = 2, Middle = 3, Richer = 4, Richest = 5)	
Education Level	V106 (No Education = 1, Primary = 2, Secondary = 3, Higher = 4)	
Type of Residence	V025 (Urban = 1, Rural = 2)	
Birth Order	BORD (1st Birth Order = 1, 2nd Birth Order = 2, 3rd Birth Order = 3, 4 & above Birth Order = 4)	
BMI	V445 (Normal = 1, Underweight = 2, Overweight = 3, Obese = 4)	
Child Weight	HW2	
Child Height	HW3	
Birth Weight (gm)	M19 (< 2000 = 1, 2000 – 2499 = 2, 2500 – 2999 = 3, 3000 + = 4)	NFHS-4
Stunted	HW70 (Yes = 1, No = 0)	
Underweight	HW71 (Yes = 1, No = 0)	
Wasted	HW72 (Yes = 1, No = 0)	
States/U.T.	V024 (1 = Andaman and Nicobar Islands, 2 = Andhra Pradesh, 3 = Arunachal Pradesh, 4 = Assam, 5 = Bihar, 6 = Chandigarh, 7 = Chhattisgarh, 8 = Dadra and Nagar Haveli, 9 = Daman and Diu, 10 = Goa, 11 = Gujarat, 12 = Haryana, 13 = Himachal Pradesh, 14 = Jammu and Kashmir, 15 = Jharkhand, 16 = Karnataka, 17 = Kerala, 18 = Lakshadweep, 19 = Madhya Pradesh, 20 = Maharashtra, 21 = Manipur, 22 = Meghalaya, 23 = Mizoram, 24 = Nagaland, 25 = Delhi, 26 = Odisha, 27 = Puducherry, 28 = Punjab, 29 = Rajasthan, 30 = Sikkim, 31 = Tamil Nadu, 32 = Tripura, 33 = Uttar Pradesh, 34 = Uttarakhand, 35 = West Bengal, 36 = Telangana)	

3. DATA ANALYSIS PLAN

In the present work, we have studied growth dynamics of under 5 children in terms of under nutrition as well as child height & weight in relation to their major determinants. Finally, the Nomograms (sometimes called, Growth Charts), were also prepared. Further, we utilized National Family Health Survey (NFHS) – Round 4 Data, as explained in Chapter 2, for estimating the risk factors of under nutrition as well as under 5 children's height and weight. Also, as indicated earlier (Chapter 2), before analysing the NFHS – 4 Data, we suitably divided the country into 6 geographical regions, namely – *Central Region, Eastern Region, Northern Region, Northeast Region, Western Region,* and *Southern Region*. The final analysis was done for all the 6 regions separately.

3.1 Statistical Model, Applied for Studying Growth Dynamics in terms of Stunting, Wasting and Under-weight

3.1.1 Logistic Regression

To examine the effect of predictor variables on the categorical dependent variable, Logistic Regression Analysis is applied[14]. In particular, Binary Logistic Regression is applied when a categorical dependent variable is dichotomous. The Binary Logistic Regression Model only takes into account a single response variable with a binary result when other factors are present[14]. Let $\boldsymbol{Y_i} = (Y_{1i}, Y_{2i}, Y_{3i})$ be a vector of binary responses indicating whether the i^{th} child is stunting$(Y_{1i} = 1)$, wasting$(Y_{2i} = 2)$, and under-weight $(Y_{3i} = 3)$ whereas $\boldsymbol{X_i}$ is the vector of covariates for the i^{th} child. Thus, a Binary Logistic Regression Model is given by:

$$logit\left[P\left(Y_{ij} = \frac{1}{X}\right)\right] = \beta_{1j}x_{i1} + \beta_{2j}x_{i2} + \cdots + \beta_{pj}x_{ip} = X\beta_j; j = 1,2,3$$

where β_j is a vector of covariate coefficients, which explains how covariates affect the dependent variables. $P\left(Y_{ij} = \frac{1}{X}\right)$ is the probability of the i^{th} child being stunting (Y_{1i}), wasting (Y_{2i}), and under-weight (Y_{3i}) given other covariates X. These probabilities can be computed as:

$$P(Y_{ij} = 1) = \frac{e^{\beta_{1j}x_{i1} + \beta_{2j}x_{i2} + \cdots + \beta_{pj}x_{ip}}}{1 + e^{\beta_{1j}x_{i1} + \beta_{2j}x_{i2} + \cdots + \beta_{pj}x_{ip}}} = \frac{e^{X\beta_j}}{1 + e^{X\beta_j}}$$

The effect of covariates on the dependent variables (Y_{ij}) is commonly interpreted using the odds ratio. Odds ratio (OR_j) is the ratio of two odds and is defined as:

$$OR_j = \frac{Odds_{j1}}{Odds_{j2}} = \frac{\pi_j(x_1)/\left(1 - \pi_j(x_1)\right)}{\pi_j(x_2)/\left(1 - \pi_j(x_2)\right)}$$

where $\pi_j(x_1)$ and $\pi_j(x_2)$ are the probability of a child being stunting $(Y_{1i} = 1)$, wasting $(Y_{2i} = 2)$, and under-weight $(Y_{3i} = 3)$ for the values of variables, X are x_1 and x_2 respectively.

3.1.1.1 Assumptions of Logistic Regression

Logistic Regression does not require many of the principal assumptions of linear regression models that are based on ordinary least squares method – particularly regarding linearity of relationship between the dependent and independent variables, normality of the error distribution, homo-scedasticity of the errors, and measurement level of the independent variables. Logistic Regression can handle non – linear relationships between the dependent and independent variables, because it applies a non – linear log transformation. The error terms (the residuals) do not need to be multivariate normally distributed although multivariate normality yields a more stable solution. The variance of errors can be hetero-scedastic for each level of the independent variables. Logistic Regression can handle not only continuous data but also discrete data as independent variables.

However, some other assumptions still apply[75, 76]: Firstly, Logistic Regression requires the dependent variables to be probability dichotomous. Secondly, since Logistic Regression estimates the probability of the event occurring $\left(P(Y=1)\right)$, it is necessary to code the dependent variable accordingly. That is, the desired outcome should be coded to be 1. Thirdly, model should be fitted correctly. It should not be over fitted with the meaningless variables included. Fourthly, Logistic Regression requires each observation to be independent. Also, model should have no multicollinearity.

3.1.1.2 Odds Ratios with 95% Confidence Interval

An odds ratio (OR) with a 95% confidence interval (CI) can be used to assess the contribution of individual predictors. The 95% CI is used to estimate the precision of OR. A large CI indicates a low level of precision of the OR, whereas a small CI indicates higher precision of the OR. An approximation for the confidence interval for the population is, the log odds ratio,

$$95\%\ CI\ for\ the\ ln(OR) = ln(OR) \pm 1.96 \times \{SE\left(ln(OR)\right)\}$$

where $ln(OR)$ is the log odds ratio and, $SE\left(ln(OR)\right)$ is the standard error of the log odds ratio. Taking antilog, a 95% confidence interval for the odds ratio is given as:

$$95\%\ CI\ for\ OR = e^{ln(OR) \pm 1.96 \times \{SE\left(ln(OR)\right)\}}.$$

3.2 Statistical Model, Applied for Major Determinants of Growth in terms of Child Height & Weight

3.2.1 Generalized Linear Models

Generalized Linear Models are extension of classical linear models. A vector of observations $\boldsymbol{y}$ having n components is assumed to be a realization of a random variable $\boldsymbol{Y}$ whose components are independently distributed with mean $\boldsymbol{\mu}$. The systematic part of the model is a specification for the vector $\boldsymbol{\mu}$ in terms of a small number of unknown parameters $\beta_1, \dots, \beta_p$. In the case of ordinary linear models, this specification takes the form

$$\mu = \sum_{1}^{p} \boldsymbol{x_j}\beta_j \qquad \dots\dots..(1)$$

where the βs are parameters, whose values are usually unknown and have to be estimated from the data. If we let i index the observations then the systematic part of the model may be written

$$E(Y_i) = \mu_i = \sum_{1}^{p} x_{ij}\beta_j; \qquad \dots\dots\dots\dots\dots(2)$$

where x_{ij} is the value of the jth covariate for observation i. In matrix notation (where $\boldsymbol{\mu}$ is $n \times 1$, $\boldsymbol{X}$ is $n \times p$ and $\boldsymbol{\beta}$ is $p \times 1$) we may write

$$\boldsymbol{\mu} = \boldsymbol{X\beta}$$

where $\boldsymbol{X}$ is the model matrix and $\boldsymbol{\beta}$ is the vector of parameters. This completes the specification of the systematic part of the model.

For the random part, we assume independence and constant variance of errors. Similarly, the structure of the systematic part assumes that we know the covariates that influence the mean and can measure them effectively without error. A further specialization of the model involves stronger assumption that the errors follow a Gaussian or Normal Distribution with constant variance σ^2.

We may thus, summarize the classical linear model in the form:

The components of $\boldsymbol{Y}$ are independent normal variables with constant variance σ^2 and

$$\boldsymbol{E}(\boldsymbol{Y}) = \boldsymbol{\mu} \text{ and } \boldsymbol{\mu} = \boldsymbol{X\beta} \ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

3.2.1.1 *The Generalization*

To simplify the transition to Generalized Linear Models, we shall rearrange (3) slightly to produce the following 3-part specification:

1) *The random component:* the components of $\boldsymbol{Y}$ have independent Normal Distributions with $\boldsymbol{E}(\boldsymbol{Y}) = \boldsymbol{\mu}$ and constant variance σ^2;
2) *The systematic component:* covariates $\boldsymbol{x_1}, \boldsymbol{x_2}, \ldots., \boldsymbol{x_p}$ produce a *linear predictor* $\boldsymbol{\eta}$ given by

$$\eta = \sum_{1}^{p} \boldsymbol{x_j} \beta_j;$$

3) The *link* between the random and systematic components:

$$\boldsymbol{\mu} = \boldsymbol{\eta}.$$

This generalization introduces a new symbol η for the linear predictor and the third component then specifies that μ and η are in fact identical. If we write,

$$\eta_i = g(\mu_i),$$

then $g(.)$ will be called the *link* function. In this formulation, classical linear models have a Normal (or Gaussian) Distribution in the component (a) and the identity function for the link in the component (c). Generalized Linear Models allow two extensions; first the distribution in the component (a) may come from an exponential family other than the Normal, and secondly, the link function in the component (c) may become a monotonic differentiable function.

We look first at the extended distributional assumption.

3.2.1.2 Likelihood Functions for Generalized Linear Models

We assume that each component of $\boldsymbol{Y}$ has a distribution in the exponential family, taking the form,

$$f_Y(y;\theta,\phi) = exp\{(y\theta - b(\theta))/a(\phi) + c(y,\phi)\} \ldots\ldots\ldots..(4)$$

for some specific functions $a(.), b(.)$ and $c(.)$. If ϕ is known, this is an exponential family model with canonical parameter θ. It may or may not be two–parameter exponential family if ϕ is unknown. Thus, for the Normal Distribution

$$f_Y(y;\theta,\phi) = \frac{1}{\sqrt{(2\pi\sigma^2)}} exp\left\{-\frac{(y-\mu)^2}{2\sigma^2}\right\}$$

$$f_Y(y;\theta,\phi) = exp\left\{\frac{\left(y\mu - {\sigma^2}/{2}\right)}{\sigma^2} - \frac{1}{2}\left(\frac{y^2}{\sigma^2} + log(2\pi\sigma^2)\right)\right\},$$

So that $\theta = \mu, \phi = \sigma^2$, and

$$a(\phi) = \phi, b(\theta) = \frac{\theta^2}{2}, c(y,\phi) = -\frac{1}{2}\left(\frac{y^2}{\sigma^2} + log(2\pi\sigma^2)\right).$$

We write $l(\theta,\phi;y) = logf_Y(y;\theta,\phi)$ for the log-likelihood function considered as a function of θ and ϕ, y being given. The mean and variance of Y can be derived easily from well-known relations

$$E\left(\frac{\partial l}{\partial \theta}\right) = 0 \dots\dots\dots\dots\dots\dots.(5)$$

$$\text{and } E\left(\frac{\partial^2 l}{\partial \theta^2}\right) + E\left(\frac{\partial l}{\partial \theta}\right)^2 = 0 \dots\dots\dots\dots\dots.(6)$$

We have from (4)

$$l(\theta;y) = \big(y\theta - b(\theta)\big)/a(\phi) + c(y,\phi)$$

Hence,

$$\frac{\partial l}{\partial \theta} = \frac{\{y - b'(\theta)\}}{a(\phi)} \dots\dots\dots\dots\dots\dots..(7)$$

and

$$\frac{\partial^2 l}{\partial \theta^2} = -b''(\theta)/a(\phi)\dots\dots\dots\dots (8)$$

where primes denote differentiation with respect to θ.

From (5) and (7), we have

$$0 = E\left(\frac{\partial l}{\partial \theta}\right) = \frac{\{\mu - b'(\theta)\}}{a(\phi)}$$

so that

$$E(Y) = \mu = b'(\theta).$$

Similarly, from (6), (7), and (8) we have

$$0 = -\frac{b''(\theta)}{a(\phi)} + \frac{var(Y)}{a^2(\phi)}$$

so that

$$var(Y) = b''(\theta)a(\phi).$$

Thus, the variance of Y is the product of two functions; one, $b''(\theta)$, depends on the canonical parameter (and hence, the mean) only and will be called the variance function, while the other is independent of θ and depends only on ϕ. The variance function considered as a function of μ will be written $V(\mu)$.

The function $a(\phi)$is common of the form

$$a(\phi) = \frac{\phi}{w}$$

where ϕ, also denoted by σ^2 and called the dispersion parameter, is constant over observations, and w is a prior weight that varies from observation to observation. Thus, for a normal model in which each observation is the mean of m independent readings, we have

$$a(\phi) = \frac{\sigma^2}{m}$$

So that $w = m$.

3.2.1.3 Link Functions

The link function relates the linear predictor η to the expected value μ of a datum y. In classical linear models, the mean and the linear predictor are identical and the identified link is plausible in that both η and μcan take any value on the real line. However, when we are dealing with counts and the distribution is Poisson, we must have $\mu > 0$ so that the identity link is less attractive. Models for count, based on independence in cross-classified data lead naturally to multiplicative effect, and this is expressed by the log link, $\eta = \log \mu$, with its inverse $\mu = e^{\eta}$.

For the Binomial Distribution, we have $0 < \mu < 1$, and a link should satisfy the condition that it maps the interval (0,1) onto the whole real line. We shall consider three principal functions, namely,

- Logit

$$\eta = log\{\mu/(1-\mu)\}$$

- Probit

$$\eta = \phi^{-1}(\mu)$$

- Complementary log-log

$$\eta = log\{-log(1-\mu)\}$$

The power family of links is important, at least for observations with positive mean. This family can be specified either by

$$\eta = \frac{(\mu^{\lambda}-1)}{\lambda}$$

with limiting value

$$\eta = \log \mu; \text{ as } \lambda \to 0$$

or by

$$\eta = \begin{cases} \mu^{\lambda};\ \lambda \neq 0 \\ \log \mu\ ;\ \lambda = 0 \end{cases}$$

The first form has the advantage of a smooth transition as λ passes through zero, but with either form special action has to be taken in any computation with $\lambda = 0$.

3.3 Statistical Models Applied for Child Growth Nomograms

In the present Study, we utilized NFHS-4 Data for estimating child growth. Eleven statistical models given below, which were available in SPSS Software were fitted to the observed data of children below the age of five years on height & weight by age (months) for boys and girls separately, for each of the 4 birth-weight categories in all six Regions of country.

a) $Linear\ Model\colon\ E(Y_t) = \beta_0 + \beta_1 t$

b) $Logarithmic\ Model\colon\ E(Y_t) = \beta_0 + \beta_1 \ln(t)$

c) $Inverse\ Model\colon\ E(t) = \beta_0 + \beta_1/t$

d) $Quadratic\ Model\colon\ E(Y_t) = \beta_0 + \beta_1 t + \beta_2 t^2$

e) $Cubic\ Model\colon\ E(Y_t) = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3$

f) $Compound\ Model\colon\ E(Y_t) = \beta_0 \beta_1^t$

g) $Power\ Model\colon\ E(Y_t) = \beta_0 t^{\beta_1}$

h) $S\ Model\colon\ E(Y_t) = \exp(\beta_0 + \beta_1/t)$

i) $Growth\ Model\colon\ E(Y_t) = \exp(\beta_0 + \beta_1 t)$

j) $Exponential\ Model\colon\ E(Y_t) = \beta_0 e^{\beta_1 t}$

k) $Logistic\ Model\colon\ E(Y_t) = \left(\frac{1}{u} + \beta_o \beta_1^t\right)^{-1}$

Children of all 6 Regions were first divided into 4 sub-categories according to their birth

weight:$(i) < 2000\ gm, (ii)\ 2000 - 2499\ gm, (iii)\ 2500 - 2999\ gm, (iv)\ 3000\ gm +$.

Then, growth curves for height as well as weight were estimated for under five children for two sexes separately (i.e., both boys and girls), using 11 statistical models mentioned above {From (a) to (k)}.

The Goodness of Fit of the model was based on the highest values of R^2 (Coefficient of Determination) of the model, out of 11 statistical models used. Our analysis showed that out of 11 statistical models given above {From (a) to (k)}, only two statistical models, namely – *Cubic Model* and *Power Model* fitted best to the data of various birth weight categories.

3.4 Statistical Software Applied for Data-Analysis

In the present work, Generalized Linear Model and the above suggested statistical models were used. In addition, Logistic Regression Model was used to study the determinants of stunting, wasting and underweight and Generalized Linear Model was used to study determinants of child - height and child-weight of children below the 5 years of age, using IBM SPSS Version 22. Further, MS Excel was used to prepare the Region – Specific Growth - Nomograms, considering height and weight by age (months) for various birth – weight categories for two sexes separately for each of the 6 geographic Regions.

4. RESULTS

As indicated in Chapter 2, secondary data, obtained from the NFHS-4 of the country were used for the purpose of this Study. Under-nutrition of children below 5 years of age in the country was studied, region-wise. Thus, for present analysis, the country was suitably divided into 6 different regions, namely – Central Region, Eastern Region, Northern Region, Northeast Region, Western Region, and Southern Region. Status of children's under-nutrition, role of major socio-economic & demographic factors, children's growth dynamics and some other related aspects were studied, applying appropriate statistical models and other relevant methods. The results of the analysis are presented in the following sections for all the 6 geographical Regions separately.

4.1 Central Region

This Region consists of 3 States, namely - Chhattisgarh, Madhya Pradesh, and Uttar Pradesh.

4.1.1 Status of Under-Nutrition

Table 4.1.1: Prevalence rates (%) of stunting, wasting, and underweight.

Central Region	Stunting	Wasting	Underweight
	38.4	**18.8**	**35.6**
Chhattisgarh	37.6	23.1	37.7
Madhya Pradesh	42.0	25.8	42.8
Uttar Pradesh	46.2	17.9	39.5

Figure 4.1.1: Prevalence rates (%) of stunting, wasting, and underweight.

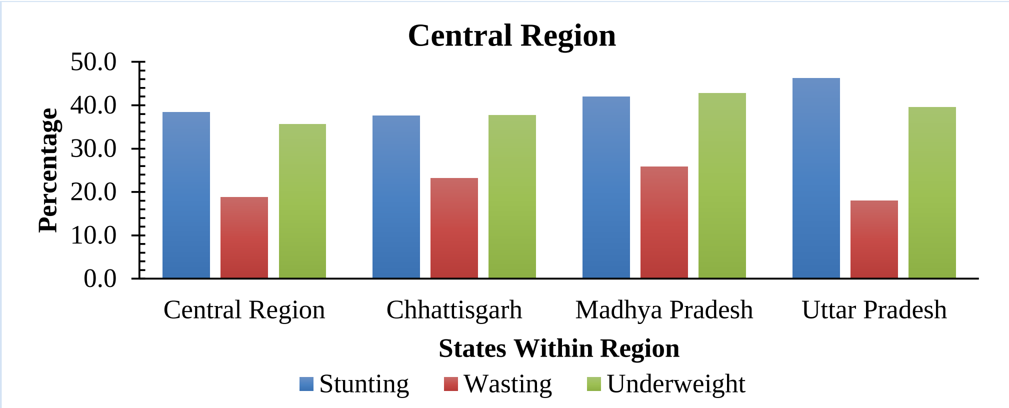


Table 4.1.1 and Figure 4.1.1 show prevalence rates of stunting, wasting and underweight in the Central Region. Stunting ranged between 37.6% (Chhattisgarh) and 46.2% (UP). Wasting was highest (25.8%) in MP and lowest (17.9%) in UP. The prevalence of underweight was highest (42.8%) in MP and lowest (37.7%) in Chhattisgarh.

4.1.2 Stunting

Table 4.1.2 represents odd ratio of stunting in under-5 children by socio-demographic variables in Central Region of India. Children aged 12 – 23 months (OR = 2.91, 95% CI: 2.76 – 3.07, $p < 0.001$) had 2.9 times higher odds of being stunted as compared to the children aged below 12 months. Children aged 24 to 35 months faced three times higher odds in experiencing stunted growth (OR = 3.07, 95% CI: 2.92 – 3.24, $p < 0.001$) compared to those under 12 months of age. Children born in the age group 36 to 47 months (OR = 3.02, 95% CI: 2.86 – 3.18, $p < 0.001$) had 3 times higher odds of being stunted compared to the children less than 12 months. Children born in the age group of 48 to 59 months (OR = 2.38, 95% CI: 2.26 – 2.51, $p < 0.001$) had odds of being stunted that were 2.3 times higher compared to children less than 12 months. Male children (OR = 1.07, 95% CI: 1.03 – 1.10, $p < 0.001$) exhibited significantly higher odds of being stunted compared to female children.

As compared to the richest group, the odds of having stunted children were 2.3 times higher in the poorest group (OR: 2.33, 95% CI: 2.16 – 2.51, $p < 0.001$). The odds of having stunted children were 2.1 times higher in the poorer group (OR: 2.11, 95% CI: 1.96 – 2.27, $p < 0.001$) when compared to the richest group. In middle group (OR: 1.76, 95% CI: 1.64 – 1.89, $p < 0.001$) odds of stunting in children were 1.7 times higher compared to richest group. The odds of having a stunted child were higher in the richer group (OR: 1.40, 95% CI: 1.30 – 1.50, $p < 0.001$) than in the richest group.

Mother having no education (OR: 1.95, 95% CI: 1.81 – 2.11, $p < 0.001$) compared with mother's higher level of education had 1.9 times higher odds of being stunted children. The odds of stunting children were 1.7 times higher for mother having only primary education (OR: 1.71, 95% CI: 1.58 – 1.85, $p < 0.001$) compared to those with higher levels of education. Mother with secondary education had 1.4 times higher odds of being stunted children than mother with higher levels of education (OR: 1.46, 95% CI: 1.36 – 1.56, $p < 0.001$). The odds of having stunted children were 11% lower in rural areas (OR: 0.89, 95% CI: 0.85 – 0.94, $p < 0.001$) compared to urban areas.

The odds of stunted children were significantly higher in second birth order as compared to first birth order (OR: 1.03, 95% CI: 0.99 – 1.07, $p = 0.180$). There is no significant difference in the likelihood of stunting of children in the 2^{nd} Birth Order as compared to the 1^{st} Birth Order. Comparing the third birth order to the first, the odds of a child being stunted was significantly higher (OR: 1.07, 95% CI: 1.02 – 1.13, $p = 0.004$). For birth order 4 and higher compared to first birth order, the odds of a child being stunted was 1.2 times higher (OR: 1.21, 95% CI: 1.16 – 1.27, $p < 0.001$). Underweight mother (OR: 1.17, 95% CI: 1.13 – 1.21, $p < 0.001$) had 1.2 times higher odds of stunting children than normal mother (OR: 1.17, 95% CI: 1.13 – 1.21, $p < 0.001$). When compared to normal mothers, overweight mothers (OR: 0.79, 95% CI: 0.74 – 0.84, $p < 0.001$) had 21% lower odds of having stunted children. In comparison to normal mothers, obese mothers had 26% lower odds of having stunted children (OR: 0.74, 95% CI: 0.65 – 0.83, $p < 0.001$).

Table 4.1.2: - Odds Ratios of stunting in under-5 children by socio-demographic variables in Central Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower	Upper
Child Age (Month)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.91	2.76	3.07
24 - 35	0.000	3.07	2.92	3.24
36 - 47	0.000	3.02	2.86	3.18
48 - 59	0.000	2.38	2.26	2.51
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.07	1.03	1.10
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.33	2.16	2.51
Poorer	0.000	2.11	1.96	2.27
Middle	0.000	1.76	1.64	1.89
Richer	0.000	1.40	1.30	1.50
Mother's Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.95	1.81	2.11
Primary	0.000	1.71	1.58	1.85
Secondary	0.000	1.46	1.36	1.56
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.00	0.89	0.85	0.94
Birth Order				
1 *(Ref)*		1.00		
2	0.180	1.03	0.99	1.07
3	0.004	1.07	1.02	1.13
4 & above	0.000	1.21	1.16	1.27
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.17	1.13	1.21
Overweight	0.000	0.79	0.74	0.84
Obese	0.000	0.74	0.65	0.83

Diagnostic Evaluation of Logistic Regression

Table 4.1.3 reveals the sensitivity and specificity of the model at 62.4%. However, sensitivity and specificity can be changed depending on the research's needs and the need for diagnostic research. Area under the ROC curve is 0.667 (95% CI: 0.663 – 0.671) (Figure 4.1.2).

Figure 4.1.2: - Receiving Operative Characteristic (ROC) Curve, highlighting the results for stunting in Central Region of India

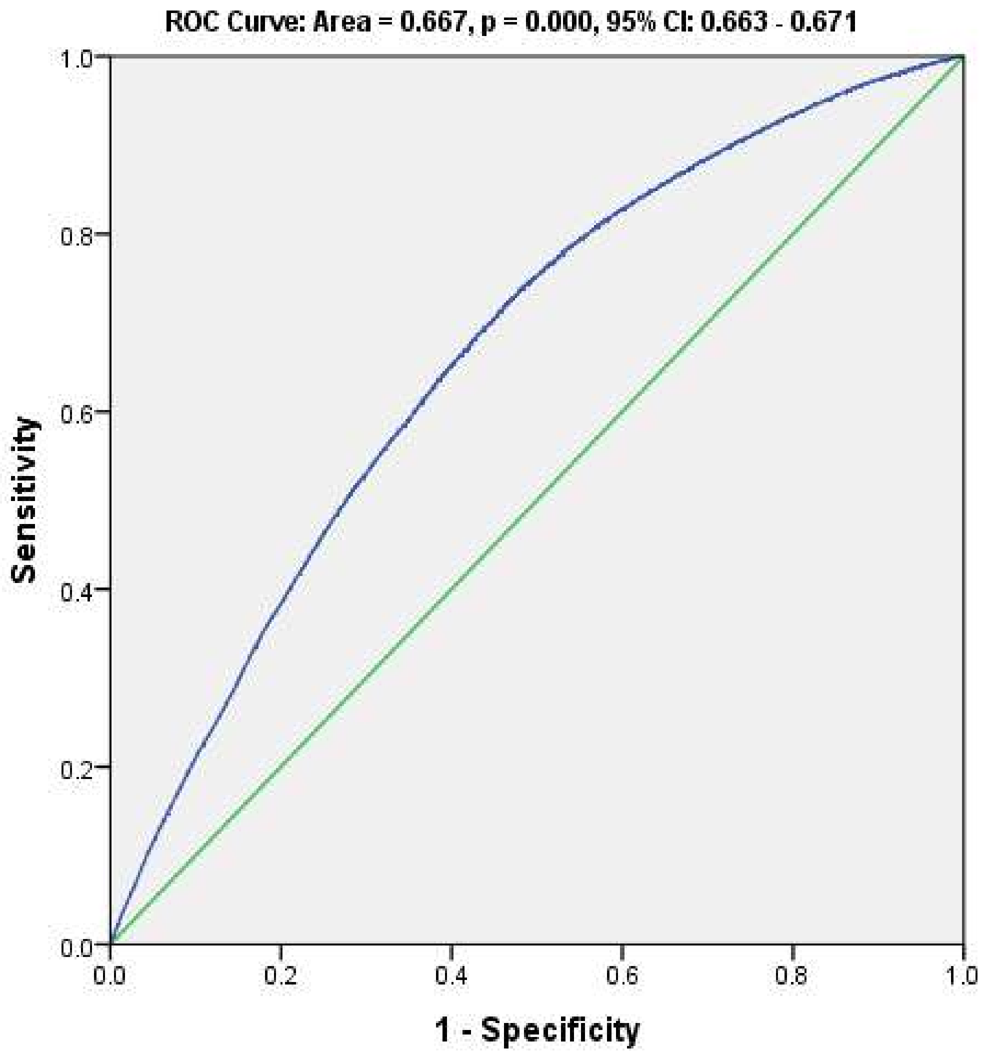


Table 4.1.3: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	**Sensitivity**	**Specificity**
0.2144202	0.970	0.111
0.2154176	0.969	0.114
0.2350885	0.959	0.141
0.2559146	0.939	0.187
0.2656028	0.929	0.212
0.2752405	0.919	0.232
0.3420473	0.839	0.381
0.3556398	0.818	0.415
0.3647155	0.809	0.428
0.3702479	0.799	0.441
0.3791669	0.789	0.455
0.3873445	0.779	0.468
0.3947566	0.769	0.480
0.4022172	0.759	0.492
0.4104142	0.749	0.504
0.4183133	0.739	0.516
0.4246532	0.729	0.526
0.4311884	0.719	0.537
0.4408792	0.699	0.555
0.4469048	0.689	0.566
0.4515826	0.679	0.576
0.4560232	0.669	0.584
0.4626506	0.659	0.593
0.4680235	0.648	0.604
0.4692504	0.646	0.606
0.4721380	0.638	0.613
0.4789833	**0.624**	**0.624**
0.4805592	0.619	0.628
0.4794555	0.621	0.626
0.4804113	0.620	0.627
0.4805592	0.619	0.628
0.5231021	0.490	0.731
0.5564452	0.367	0.811
0.6285519	0.089	0.962

4.1.3 Wasting

Table 4.1.4: - Odds Ratios of wasting in under-5 children by socio-demographic variables in Central Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower	Upper
Child Age				
< 12 *(Ref)*		1		
12 - 23	0.000	0.66	0.63	0.70
24 - 35	0.000	0.54	0.51	0.57
36 - 47	0.000	0.47	0.45	0.50
48 - 59	0.000	0.45	0.42	0.47
Child Sex				
Female *(Ref)*		1		
Male	0.000	1.19	1.14	1.23
Birth Order				
1 *(Ref)*		1		
2	0.789	0.99	0.95	1.04
3	0.120	0.96	0.90	1.01
4 & above	0.832	0.99	0.94	1.05
BMI (Kg/m^2)				
Normal *(Ref)*		1		
Underweight	0.000	1.39	1.33	1.45
Overweight	0.000	0.64	0.59	0.70
Obese	0.000	0.46	0.38	0.55
Mother's Education Level				
Higher *(Ref)*		1		
No Education	0.271	1.05	0.96	1.15
Primary	0.270	1.05	0.96	1.15
Secondary	0.355	1.04	0.96	1.13
Type of Residence				
Urban *(Ref)*		1		
Rural	0.014	0.94	0.89	0.99
Wealth Index				
Richest *(Ref)*		1		
Poorest	0.000	1.37	1.26	1.50
Poorer	0.005	1.13	1.04	1.23
Middle	0.009	1.12	1.03	1.21
Richer	0.122	1.07	0.98	1.16

Table 4.1.4 shows odds ratios of wasting in under 5 children by socio-demographic variables in the Central Region. In comparison to children under the age of 12 months, the odds of a child being wasted were 34% lower in the 12 to 23-month age group (OR: 0.66, 95% CI: 0.63 – 0.70, $p < 0.001$). The odds of a child being wasted were 46% lower in the 24 to 35-month age group (OR: 0.54, 95% CI: 0.51 – 0.57, $p < 0.001$) when compared to children under the age of 12 months. The odds of a child being wasted were 53% lower in the 36 to 47-month age group (OR: 0.47, 95% CI: 0.45 – 0.50, $p < 0.001$) as compared to children under the age of 12 months. In the 48 to 59-month age group (OR: 0.45, 95% CI: 0.42 – 0.47, $p < 0.001$), the odds of a child being wasted was 55% lower compared to that of children under the age of 12 months. Male children (OR: 1.19, 95% CI: 1.14 – 1.23, $p < 0.001$) experienced significantly higher odds of having a wasted than female children.

As compared to the first birth order, second birth order (OR: 0.99, 95% CI: 0.95 – 1.04, $p = 0.789$) as well as birth order four and above (OR: 0.99, 95% CI: 0.94 – 1.05, $p = 0.832$), the odds of being wasted children were 1% lower. The odds of having wasted children were 4% lower in the third birth order (OR: 0.96, 95% CI: 0.90 – 1.01, $p = 0.120$) compared to the first. When compared to the first birth order, there is no clear change in the likelihood of wasted children in the second, third, fourth, and higher birth orders.

In comparison to normal mothers, underweight mothers (OR: 1.39, 95% CI: 1.33 – 1.45, $p < 0.001$) had 1.3 times higher odds of having wasted children. Overweight mothers (OR: 0.64, 95% CI: 0.59 – 0.70, $p < 0.001$) had 36% lower odds of having wasted children than normal mothers. Obese mothers (OR: 0.46, 95% CI: 0.38 – 0.55, $p < 0.001$) had a 54% lower chance of having wasted children than normal mothers.

In comparison to mothers with higher levels of education, mothers without any formal education (OR: 1.05, 95% CI: 0.96 – 1.15, p = 0.271) and those with only a primary education (OR: 1.05, 95% CI: 0.96 – 1.15, p = 0.270) had higher odds of having wasted children. As compared to mothers with higher levels of education, mothers with secondary education (OR: 1.04, 95% CI: 0.96 – 1.13, p = 0.355) had significantly higher odds of having wasted children. In comparison to mothers with higher education levels, there is no meaningful difference between the odds of wasted children among women with no formal education, those with primary education, and those with secondary education. The odds of having wasted children were 6% lower in rural areas (OR: 0.94, 95% CI: 0.89 – 0.99, p = 0.014) than in urban areas.

The odds of having wasted children were 1.3 times higher in the poorest group (OR: 1.37, 95% CI: 1.26 – 1.50, p < 0.001) than in the richest group. In comparison to the richest group, the odds of having wasted children were significantly higher in the poorer group (OR: 1.13, 95% CI: 1.04 – 1.23, p = 0.005). In comparison to the richest group, the odds of having wasted children were significantly higher in the middle group (OR: 1.12, 95% CI: 1.03 – 1.21, p < 0.009). In the richer group (OR: 1.07, 95% CI: 0.98 – 1.16, p = 0.122) compared to the richest group, the odds of having wasted children were also significantly higher. The likelihood of wasted children in the richer group compared to the richest group is not significantly different.

Diagnostic Evaluation of Logistic Regression

Table 4.1.5, depicts the model's sensitivity and specificity are respectively 58.5% and 58.4%. Sensitivity and specificity, however, may change based on the requirements of the research and the need for diagnostic research. Area under the ROC curve is 0.617 (95% CI: 0.612 – 0.622) (Figure 4.1.3).

Figure 4.1.3: - Receiving Operative Characteristic (ROC) Curve, highlighting the results for wasting of under-5 children in the Central Region of India

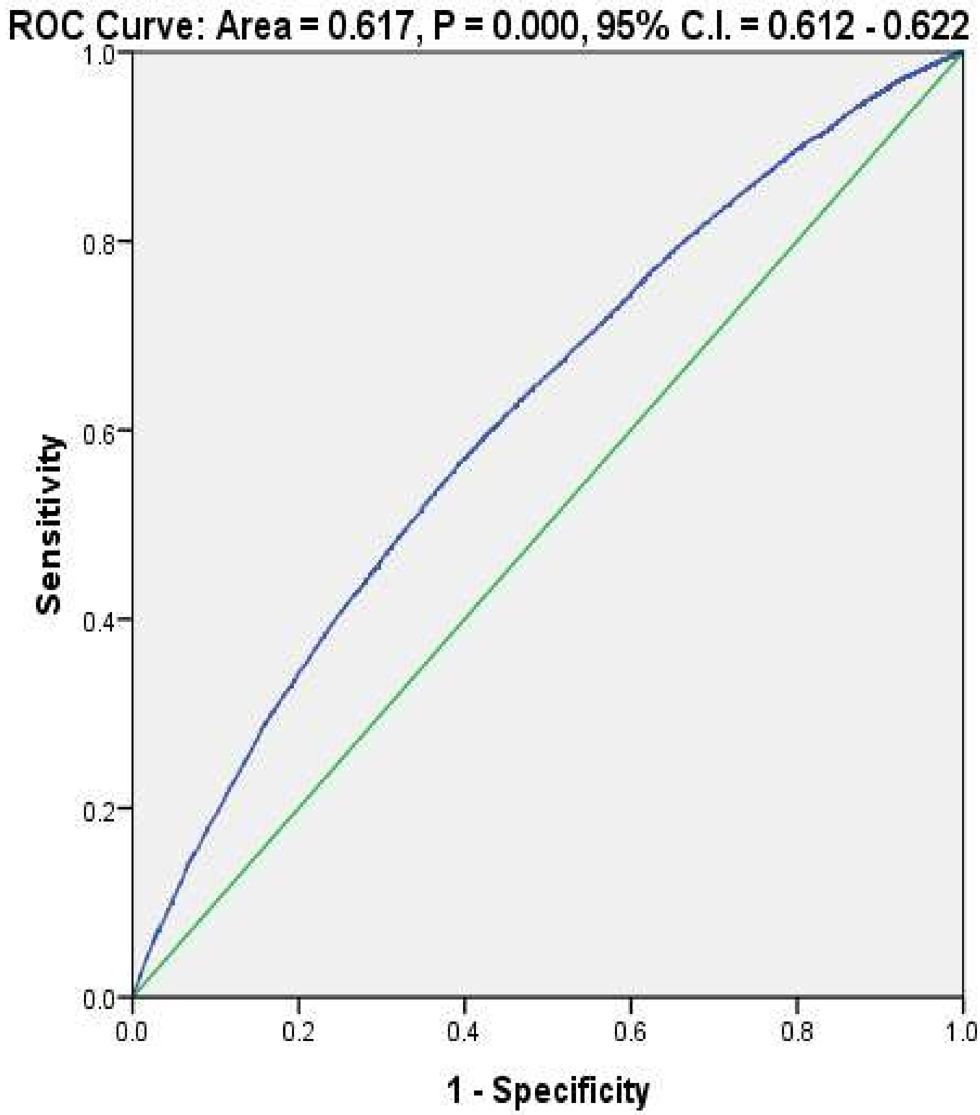


Table 4.1.5: - Sensitivity & Specificity of the Model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.1206733	0.970	0.076
0.1214447	0.969	0.078
0.1320386	0.959	0.094
0.1374858	0.949	0.114
0.1416291	0.939	0.131
0.1431870	0.929	0.147
0.1467924	0.919	0.161
0.1522881	0.899	0.196
0.1570626	0.889	0.211
0.1592091	0.879	0.225
0.1624413	0.869	0.240
0.1639075	0.859	0.255
0.1651516	0.849	0.269
0.1664293	0.839	0.281
0.1675392	0.829	0.296
0.1736213	0.789	0.349
0.1762755	0.776	0.363
0.1771181	0.769	0.374
0.1787511	0.759	0.384
0.1828661	0.749	0.396
0.1849256	0.739	0.405
0.1871546	0.729	0.416
0.1885596	0.719	0.428
0.1919049	0.699	0.452
0.1935949	0.684	0.472
0.1937949	0.679	0.476
0.1948050	0.669	0.486
0.1960416	0.659	0.499
0.2006244	0.629	0.536
0.2025174	0.617	0.549
0.2034988	0.609	0.556
0.2118229	0.590	0.579
0.2136200	**0.585**	**0.584**
0.2146026	0.579	0.590
0.2170244	0.568	0.602
0.2170512	0.568	0.603
0.2172542	0.567	0.604
0.2173127	0.566	0.605
0.2176092	0.564	0.606
0.2179841	0.563	0.608

4.1.4 Underweight

Table 4.1.6: - Odds Ratio of underweight in under-5 children by socio-demographic variables in the Central Region

Socio-demographic Variables	p - value	OR	95% C.I. for OR	
			Lower	Upper
Child Age				
< 12 *(Ref)*		1		
12 - 23	0.000	1.41	1.34	1.49
24 - 35	0.000	1.55	1.48	1.63
36 - 47	0.000	1.53	1.45	1.61
48 - 59	0.000	1.44	1.37	1.51
Child Sex				
Female *(Ref)*		1		
Male	0.001	1.06	1.02	1.09
Birth Order				
1 *(Ref)*		1		
2	0.018	1.05	1.01	1.10
3	0.019	1.06	1.01	1.11
4 & above	0.000	1.14	1.09	1.20
BMI				
Normal *(Ref)*		1		
Underweight	0.000	1.55	1.49	1.60
Overweight	0.000	0.66	0.62	0.70
Obese	0.000	0.55	0.49	0.63
Mother's Educational Level				
Higher *(Ref)*		1		
No Education	0.000	1.76	1.63	1.90
Primary	0.000	1.61	1.49	1.75
Secondary	0.000	1.39	1.30	1.50
Type of Residence				
Urban *(Ref)*		1		
Rural	0.000	0.87	0.83	0.91
Wealth Index				
Richest *(Ref)*		1		
Poorest	0.000	2.15	2.00	2.32
Poorer	0.000	1.79	1.66	1.92
Middle	0.000	1.54	1.43	1.65
Richer	0.000	1.34	1.25	1.44

Table 4.1.6 represents odd ratios for the associations of variables with underweight in children under the age of five in the Central Region of India. The odds of a child being underweight in the 12 to 23month age group (OR: 1.41, 95% CI: 1.34 – 1.49, $p < 0.001$) as well as the 48 to 59month age group (OR: 1.44, 95% CI: 1.37 – 1.51, $p < 0.001$) were 1.4 times higher than in children under the age of 12 months. The odds of a child being underweight was 1.5 times higher in the 24 to 35month age group (OR: 1.55, 95% CI: 1.48 – 1.63, $p < 0.001$) as well as the 36 to 47month age group (OR: 1.53, 95% CI: 1.45 – 1.61, $p < 0.001$) when compared to children under the age of 12 months. Children who were male (OR: 1.06, 95% CI: 1.02 – 1.09, $p < 0.001$) experienced significantly higher odds of being underweight than those who were female.

In comparison to first birth order, second birth order (OR: 1.05, 95% CI: 1.01 – 1.10, $p <0.05$) had significantly higher odds of having underweight children. As compared to the first birth order, third birth order (OR: 1.06, 95% CI: 1.01 – 1.11, $p = 0.019$) had significantly higher odds of having underweight children. Similarly, for birth order 4 and above (OR: 1.14, 95% CI: 1.09 – 1.20, $p < 0.001$) compared to the first birth order, the odds of a child being underweight was also significantly higher.

There were around 2 times higher odds of having underweight children in mothers with underweight BMI (OR: 1.55, 95% CI: 1.49 – 1.60, $p < 0.001$) compared to mothers with normal BMI. Children who were underweight had 34% lower odds of being born to mothers with overweight BMI (OR: 0.66, 95% CI: 0.62 – 0.70, $p < 0.001$) compared to mothers with normal BMI and similarly, in comparison to mothers with normal BMI, mothers with obese BMI (OR: 0.55, 95% CI: 0.49 – 0.63, $p < 0.001$) had 45% lower odds of giving birth to underweight children

The odds of having underweight children were 1.7 times higher for mothers with no education (OR: 1.76, 95% CI: 1.63 – 1.90, $p < 0.001$) than for mothers with higher education levels. The odds of having underweight children were 1.6 times higher for mothers with only a primary education (OR: 1.61, 95% CI: 1.49 – 1.75, $p < 0.001$) than for mothers with higher education levels. The odds of having underweight children were 1.3 times higher for mothers with secondary education (OR: 1.39, 95% CI: 1.30 – 1.50, $p < 0.001$) than for mothers with higher education levels. As compared to urban regions, rural regions (OR: 0.87, 95% CI: 0.83 – 0.91, $p < 0.001$) had 13% lower odds of having children who were overweight.

The odds of having underweight children were 2.1 times higher in the poorest group (OR: 2.15, 95% CI: 2.00 – 2.32, $p < 0.001$) than in the richest group. The odds of having underweight children were 1.7 times higher in the poorer group (OR: 1.79, 95% CI: 1.66 – 1.92, $p < 0.001$) compared to the richest group. The odds of having underweight children were 1.5 times higher in the middle group (OR: 1.54, 95% CI: 1.43 – 1.65, $p < 0.001$) than in the richest group, and similarly, the odds of having underweight children were 1.3 times higher for the richer group (OR: 1.34, 95% CI: 1.25 – 1.44, $p < 0.001$) as compared to the richest group.

Diagnostic Evaluation of Logistic Regression

Table 4.1.7 shows that the model's sensitivity and specificity is 59.9%. However, depending on the demands of the research and the requirement for diagnostic research, sensitivity and specificity might be altered. Area under the ROC curve is 0.637 (95% CI: 0.633 – 0.641) (Figure 4.1.4).

Figure 4.1.4: - Receiving Operating Characteristics (ROC) Curve highlighting results for underweight in Central Region of India

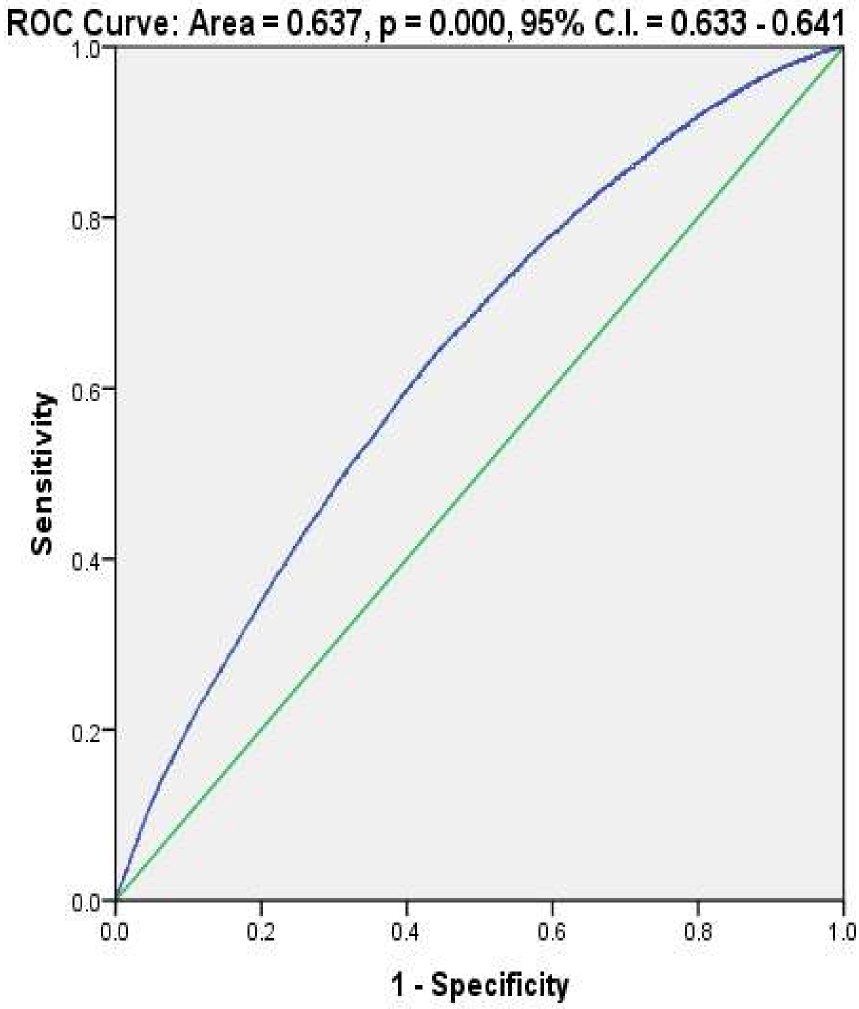


Table 4.1.7: - Sensitivity & Specificity of the Model at a different cut of points

Positive (≥)	**Sensitivity**	**Specificity**
0.2204939	0.970	0.098
0.2214341	0.969	0.101
0.2352335	0.959	0.122
0.2467763	0.949	0.143
0.2613109	0.939	0.161
0.2717221	0.929	0.182
0.2760439	0.919	0.199
0.2840419	0.909	0.215
0.2910019	0.899	0.233
0.3001395	0.889	0.247
0.3021805	0.879	0.260
0.3109650	0.869	0.275
0.3176140	0.859	0.291
0.3241967	0.849	0.307
0.3324031	0.838	0.323
0.3360511	0.829	0.338
0.3427632	0.817	0.351
0.3459191	0.809	0.362
0.3504405	0.799	0.375
0.3535913	0.789	0.387
0.3583458	0.779	0.401
0.3640357	0.769	0.414
0.3667654	0.758	0.428
0.3701648	0.749	0.439
0.3756196	0.739	0.450
0.3924629	0.689	0.505
0.3970900	0.678	0.517
0.3989104	0.668	0.530
0.4010777	0.659	0.540
0.4042300	0.649	0.551
0.4099303	0.638	0.562
0.4105940	0.637	0.563
0.4126852	0.629	0.571
0.4155441	0.619	0.581
0.4168451	0.608	0.590
0.4200910	**0.599**	**0.599**
0.4238661	0.589	0.608
0.4239570	0.588	0.609
0.4276647	0.579	0.616
0.4301565	0.569	0.625

4.1.5 Estimation of Child Height

Table 4.1.8 representing the test between subjects' effects, reveals child age, birth order, educational level, respondent occupation, wealth index, sex of child and BMI have significant effect on Child Height except type of residence.

Table 4.1.8: Tests of between-subjects effects

Dependent variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	P - value
Intercept	Hypothesis	597.051	1	597.051	15.8	< 0.001
	Error	1899.998	50.3	37.733a		
Child Age	Hypothesis	2533.783	4	633.446	19.5	< 0.001
	Error	357357.407	11008	32.463b		
Birth Order	Hypothesis	529.913	3	176.638	5.4	<0.001
	Error	357357.407	11008	32.463b		
Education Level	Hypothesis	1731.639	3	577.213	17.7	< 0.001
	Error	357357.407	11008	32.463b		
Respondent Occupation	Hypothesis	496.318	2	248.159	7.6	< 0.001
	Error	357357.407	11008	32.463b		
Type of Residence	Hypothesis	24.074	1	24.074	0.7	0.389
	Error	357357.407	11008	32.463b		
Wealth Index	Hypothesis	2223.315	4	555.829	17.1	< 0.001
	Error	357357.407	11008	32.463b		
BMI	Hypothesis	444.456	3	148.152	4.5	0.003
	Error	357357.407	11008	32.463b		
Child Sex	Hypothesis	4430.173	1	4430.173	136.4	< 0.001
	Error	357357.407	11008	32.463b		
FIT*	Hypothesis	108420.532	1	108420.532	3339.8	< 0.001
	Error	357357.407	11008	32.463b		
Birth Weight	Hypothesis	1031.275	1	1031.275	31.8	< 0.001
	Error	357357.407	11008	32.463b		
a .001 MS (Child Sex) + .999 MS(Error)						
b MS(Error)						

Note: ***Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 53.62 + 1.72Age - 0.30Age^2 + 0.00025Age^3$$

Table 4.1.9 represents factors associated with child height in central region of India. Children born in the first birth order have a higher height (OR: 1.70, 95% CI: 1.23 – 2.35, $p < 0.05$) than children born in the 4 and above birth order. Similarly, children born in the second birth order (OR: 1.64, 95% CI: 1.19 – 2.26, $p < 0.05$) have a height higher than children born in the 4 and above birth order. Children born in the third birth order (OR: 1.05, 95% CI: 0.74 – 1.50, $p = 0.765$) have a height which is higher than children born in the 4 and above birth order.

Children's height is 80% less in mothers with no education (OR: 0.20, 95% CI: 0.13 – 0.33, $p < 0.05$) compared to mothers with higher education. Children's height is 71% less in mothers with primary education (OR: 0.29, 95% CI: 0.18 – 0.47, $p < 0.05$) compared to mothers with higher education. Children's height is 53% less in mothers with secondary education (OR: 0.47, 95% CI: 0.31 – 0.72, $p < 0.05$) compared to mothers with higher education.

Children's height is 40% less in mothers with no occupation (OR: 0.60, 95% CI: 0.44 – 0.81, $p < 0.05$) compared to agricultural mothers. As compared to agricultural mothers, the height of children is higher in mothers with other occupations (OR: 1.00, 95% CI: 0.63 – 1.57, $p = 0.982$). As compared to rural region, the height of children is more in urban region (OR: 1.14, 95% CI: 0.85 – 1.53, $p = 0.389$).

Children in the poorest group (OR: 0.16, 95% CI: 0.10 – 0.25, $p < 0.05$) have 84% less height than children in the richest group. Children in the poorer group (OR: 0.21, 95% CI: 0.13 – 0.33, $p < 0.05$) have 79% less height than children in the richest group. Children in the middle group (OR: 0.33, 95% CI: 0.21 – 0.52, $p < 0.05$) have 67% less height than children in the richest group. Children in the richer group (OR:

0.50, 95% CI: 0.32 – 0.77, $p < 0.05$) have 50% less height than children in the richest group.

The height of children with normal BMI (OR: 0.38, 95% CI: 0.17 – 0.84, $p < 0.05$) is 62% less than that of those with obese BMI. The height of children with underweight BMI (OR: 0.30, 95% CI: 0.13 – 0.69, $p < 0.05$) is 70% lesser than that of children with obese BMI. The height of children with overweight BMI (OR: 0.56, 95% CI: 0.24 – 1.31, $p = 0.180$) is 44% lesser than that of children with obese BMI. As compared to female children, height of male children (OR: 3.56, 95% CI: 2.88 – 4.41, $p < 0.05$) is 3 times higher.

Table 4.1.9: Factors associated with child height in Central Region

Dependent variable: Child Height					
Variables	B	p - value	95% CI		OR (95% CI)
			LL	UL	
Birth Order					
1	0.528	0.001	0.203	0.853	1.70 (1.23, 2.35)
2	0.492	0.003	0.171	0.814	1.64 (1.19, 2.26)
3	0.053	0.765	-0.297	0.404	1.05 (0.74, 1.50)
4 & above *(Ref.)*	0				
Education Level					
No Education	-1.593	0.000	-2.071	-1.116	0.20 (0.13, 0.33)
Primary	-1.247	0.000	-1.742	-0.753	0.29 (0.18, 0.47)
Secondary	-0.76	0.000	-1.187	-0.333	0.47 (0.31, 0.72)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	-0.513	0.001	-0.821	-0.205	0.60 (0.44, 0.81)
Others	-0.005	0.982	-0.463	0.453	1.00 (0.63, 1.57)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	0.131	0.389	-0.167	0.428	1.14 (0.85, 1.53)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-1.863	0.000	-2.332	-1.394	0.16 (0.10, 0.25)
Poorer	-1.555	0.000	-2.006	-1.104	0.21 (0.13, 0.33)
Middle	-1.109	0.000	-1.555	-0.662	0.33 (0.21, 0.52)
Richer	-0.697	0.002	-1.135	-0.259	0.50 (0.32, 0.77)
Richest *(Ref.)*	0				
BMI					
Normal	-0.974	0.018	-1.779	-0.169	0.38 (0.17, 0.84)
Underweight	-1.205	0.004	-2.031	-0.378	0.30 (0.13, 0.69)
Overweight	-0.587	0.180	-1.445	0.271	0.56 (0.24, 1.31)
Obese *(Ref.)*	0				
Child Sex					
Male	1.271	0.000	1.058	1.485	3.56 (2.88, 4.41)
Female *(Ref.)*	0				
FIT*	1.07	0.000	1.034	1.106	
Birth Weight	0.93	0.000	0.606	1.253	

Note: *Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 53.62 + 1.72Age - 0.30Age^2 + 0.00025Age^3$$

Table 4.1.10 represents the descriptive statistics of child height by birth order. The mean height of a child in first and second birth order is around 83.4 cm. The mean height of a child in third and 4 & above birth order is around 82.9 cm.

Table 4.1.10: - Descriptive statistics of Child Height by birth order

Dependent variables: Child Height				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	83.45	0.16	83.13	83.76
2	83.41	0.15	83.1	83.72
3	82.97	0.17	82.62	83.32
4 & above	82.92	0.17	82.57	83.27

Note: LL – Lower Limit, UL- Upper limit, CI – Confidence Interval

Table 4.1.11 represents a pairwise comparison of child height by birth order. Mean difference of child weight between first and third birth order (M D = 0.47, 95% CI: 0.15 to 0.79, $p < 0.05$) and first and 4 & above birth order (M D = 0.52, 95% CI: 0.20 to 0.85, $p < 0.05$) is statistically significant. Mean difference of child height between second and third birth order (M D = 0.43, 95% CI: 0.11 to 0.76, $p < 0.05$) and second and 4 & above birth order (M D = 0.49, 95% CI: 0.17 to 0.81, $p < 0.05$) is statistically significant.

Table 4.1.11: **-** Pairwise comparison of Child Height by birth order

Dependent variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
1	2	0.03	0.13	0.799	-0.23	0.3
	3	0.47*	0.16	0.004	0.15	0.79
	4 & above	0.52*	0.16	0.001	0.20	0.85
2	3	0.43*	0.16	0.008	0.11	0.76
	4 & above	0.49*	0.16	0.003	0.17	0.81
3	4 & above	0.05	0.17	0.765	-0.29	0.4
*Mean difference is significant at the 0.05 level						

Table 4.1.12 represents the descriptive statistics of child height by educational level. The mean height of a child for mothers with no education is around 82.4 cm. For mothers with primary education, average height of the child is around 82.8 cm. For mothers with secondary education, average height of the child is around 83.3 cm. Similarly, for mothers with higher education, the average child's height is around 84 cm.

Table 4.1.12: - Descriptive statistics of Child Height by educational level

Dependent variable: Child Height				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	82.49	0.15	82.18	82.81
Primary	82.84	0.18	82.48	83.20
Secondary	83.33	0.15	83.03	83.63
Higher	84.09	0.23	83.63	84.54

Table 4.1.13 represents a pairwise comparison of child height by educational level. Mean difference of child height between mothers with no education and primary (M D = - 0.34, 95% CI: - 0.66 to -0.02, p-value < 0.05) is statistically significant. Mean difference of child height between mothers with no education and secondary education (M D = -0.83, 95% CI: -1.11 to -0.55, p-value < 0.05), mothers with no education and higher education level (M D = -1.59, 95% CI: -2.07 to -1.11, p-value < 0.05) is statistically significant. Mean difference of child height between mothers with primary and secondary education (M D = -0.48, 95% CI: -0.80 to -0.16, p-value < 0.05) is statistically significant. Mean difference of child weight between mothers with primary and higher education (M D = -1.24, 95% CI: -1.74 to -0.75, p < 0.05) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.76, 95% CI: -1.18 to -0.33, p < 0.05) is statistically significant.

Table 4.1.13: **-** Pairwise comparison of Child Height by education level

Dependent variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
No education	Primary	-0.34*	0.16	0.036	-0.66	-0.02
	Secondary	-0.83*	0.14	0.000	-1.11	-0.55
	Higher	-1.59*	0.24	0.000	-2.07	-1.11
Primary	Secondary	-0.48*	0.16	0.003	-0.80	-0.16
	Higher	-1.24*	0.25	0.000	-1.74	-0.75
Secondary	Higher	-0.76*	0.21	0.000	-1.18	-0.33
*Mean difference is significant at the 0.05 level						

Table 4.1.14 represents the descriptive statistics of child height by respondent occupation. Mean height of the child for mothers with no occupation is around 82.8 cm. But, for mothers with other occupation and agricultural mothers, average height of the child is around 83.3 cm.

Table 4.1.14: **-** Descriptive statistics of Child Height by respondent's occupation

Dependent variable: Child Height				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	82.85	0.12	82.60	83.09
Others	83.35	0.21	82.94	83.77
Agriculture	83.36	0.18	82.99	83.72

Table 4.1.15 represents a pairwise comparison of child height by respondent occupation. A mean difference in child height between mothers with no occupation and mothers with other occupation (M D = -0.50, 95% CI: -0.89 to -0.12, p-value < 0.05) is statistically significant. Similarly, a mean difference in child height between mothers with no occupation and mothers doing agriculture (M D = -0.51, 95% CI: -82 to -0.20, p-value < 0.05) is statistically significant.

Table 4.1.15: **-** Pairwise comparison of Child Height by respondent's occupation

Dependent variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
No Occupation	Others	-0.50*	0.19	0.010	-0.89	-0.12
	Agriculture	-0.51*	0.15	0.001	-0.82	-0.20
Others	Agriculture	-0.005	0.23	0.982	-0.46	0.45
*Mean difference is significant at the 0.05 level						

Table 4.1.16 represents the descriptive statistics of Child Height by Type of Residence. Mean height of child urban as well as rural regions is around 83 cm.

Table 4.1.16: - Descriptive statistics of Child Height by type of residence

Dependent variable: Child Height				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	83.25	0.16	82.92	83.58
Rural	83.12	0.14	82.84	83.41

Table 4.1.17 represents a pairwise comparison of child height by Type of Residence. Mean difference of child height between urban region and rural region (M D = 0.13, 95% CI: - 0.16 to 0.42, p = 0.389), is statistically insignificant.

Table 4.1.17: - Pairwise comparison of Child Height by type of residence

Dependent variable: Child Height						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Urban	Rural	0.13	0.15	0.389	-0.16	0.42

Table 4.1.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 82 cm. In the poorer and middle groups, children's average height is around 82.6 cm and 83 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 83.5 cm and 84.2 cm.

Table 4.1.18: - Descriptive statistics of Child Height by wealth index

Dependent variable: Child Height				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	82.37	0.18	82.01	82.72
Poorer	82.68	0.17	82.33	83.03
Middle	83.12	0.18	82.76	83.49
Richer	83.53	0.19	83.16	83.91
Richest	84.23	0.19	83.84	84.62

Table 4.1.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and poorer group (M D = - 0.30, 95% CI: -0.60 to -0.01, $p < 0.05$), between poorest group and middle group (M D = -0.75, 95% CI: -1.09 to -0.41, $p < 0.05$), between poorest group and richer group (M D = -1.16, 95% CI: -1.56 to -0.76, $p < 0.05$), and between poorest group and richest group (M D = -1.86, 95% CI: -2.33 to -1.39, $p < 0.05$) is statistically significant. Mean difference of child height between poorer group and middle group (M D = -0.44, 95% CI: -0.78 to – 0.10, $p < 0.05$), between poorer group and richer group (M D = -0.85, 95% CI: -1.24 to – 0.47, $p < 0.05$), and between poorer group and richest group (M D = -1.55, 95% CI: -2.00 to -1.10, $p < 0.05$) is statistically significantly. Mean difference of child height between middle group and richer group (M D = -0.41, 95% CI: -0.80 to – 0.01, $p < 0.05$), between middle group and richest group (M D = -1.10, 95% CI: -1.55 to – 0.66, $p < 0.05$) is statistically significant. Mean difference of child height between richer group and richest group (M D = -0.69, 95% CI: -1.13 to – 0.25, $p < 0.05$) is statistically significant.

Table 4.1.19: - Pairwise comparison of Child Height by wealth index

Dependent variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Poorest	Poorer	-0.30*	0.14	0.039	-0.60	-0.01
	Middle	-0.75*	0.17	0.000	-1.09	-0.41
	Richer	-1.16*	0.20	0.000	-1.56	-0.76
	Richest	-1.86*	0.23	0.000	-2.33	-1.39
Poorer	Middle	-0.44*	0.17	0.010	-0.78	-0.10
	Richer	-0.85*	0.19	0.000	-1.24	-0.47
	Richest	-1.55*	0.23	0.000	-2.00	-1.10
Middle	Richer	-0.41*	0.20	0.042	-0.80	-0.01
	Richest	-1.10*	0.22	0.000	-1.55	-0.66
Richer	Richest	-0.69*	0.22	0.002	-1.13	-0.25
*Mean difference is significant at the 0.05 level						

Table 4.1.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 83.8 cm. Similarly, children's average height in females is around 82.5 cm.

Table 4.1.20: - Descriptive statistics of Child Height by child sex

Dependent variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	83.82	0.14	83.54	84.11
Female	82.55	0.14	82.26	82.84

Table 4.1.21 represents a pairwise comparison of child height by Child Sex. Mean difference of child height between in male children and female children (M D = 1.27, 95% CI: 1.05 to 1.48, p-value < 0.05) is statistically significant.

Table 4.1.21: - Pairwise comparison of Child Height by child sex

Dependent variable: Child Height						
Child Sex	Child Sex	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Male	Female	1.27*	0.10	0.000	1.05	1.48
*Mean difference is significant at the 0.05 level						

Table 4.1.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as in underweight BMI is around 83 cm. The average height of a child with an overweight BMI is around 83 cm. Similarly, children's average height in obese BMI is around 84 cm.

Table 4.1.22: - Descriptive statistics of Child Height by BMI

Dependent variable: Child Height				
BMI (Kg/m^2)	Mean	Std. Error	95% CI	
			LL	UL
Normal	82.90	0.10	82.70	83.11
Underweight	82.67	0.13	82.40	82.94
Overweight	83.29	0.19	82.91	83.67
Obese	83.88	0.40	83.08	84.68

Table 4.1.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.23, 95% CI: - 0.020 to 0.482, p-value = 0.071), between normal BMI and overweight BMI (M D = - 0.38, 95% CI: - 0.773 to 0.001, p-value = 0.050) is statistically insignificant. But, mean difference of child height between normal BMI and obese BMI (M D = - 0.97, 95% CI: - 1.779 to - 0.169, $p < 0.05$) is statistically significant. Mean difference of child height between underweight BMI and overweight BMI (M D = - 0.61, 95% CI: - 1.045 to - 0.190, $p < 0.05$) and between underweight BMI and obese BMI (M D = - 1.20, 95% CI: - 2.031 to - 0.378, $p < 0.05$) is statistically significant. Mean difference of child height between overweight BMI and obese BMI (M D = - 0.58, 95% CI: - 1.445 to - 0.271, p-value = 0.180) is statistically insignificant.

Table 4.1.23: - Pairwise comparison of Child Height by BMI

Dependent variable: Child Height						
BMI	BMI	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Normal	Underweight	0.23	0.12	0.071	-0.02	0.482
	Overweight	-0.38	0.19	0.050	-0.773	0.001
	Obese	-0.97*	0.41	0.018	-1.779	-0.169
Underweight	Overweight	-0.61*	0.21	0.005	-1.045	-0.190
	Obese	-1.20*	0.42	0.004	-2.031	-0.378
Overweight	Obese	-0.58	0.43	0.180	-1.445	0.271
*Mean difference is significant at the 0.05 level						

4.1.6 Estimation of Child Weight

Table 4.1.24 represents the test between subjects' effects, reveals child age, birth order, educational level, wealth index, sex of child and BMI is having a significant effect on Child Weight except respondent occupation, place of residence.

Table 4.1.24: Tests of between-subjects effects

Dependent variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p -value
Intercept	Hypothesis	6.353	1	6.353	1.315	0.326
	Error	16.34	3.382	4.831a		
Child Age	Hypothesis	674.875	4	168.719	76.266	< 0.001
	Error	24144.244	10914	2.212b		
Birth order	Hypothesis	25.51	3	8.503	3.844	0.009
	Error	24144.244	10914	2.212b		
Education Level	Hypothesis	114.913	3	38.304	17.315	< 0.001
	Error	24144.244	10914	2.212b		
Respondent Occupation	Hypothesis	3.926	2	1.963	0.887	0.412
	Error	24144.244	10914	2.212b		
Place of Residence	Hypothesis	4.475	1	4.475	2.023	0.155
	Error	24144.244	10914	2.212b		
Wealth Index	Hypothesis	223.654	4	55.914	25.275	< 0.001
	Error	24144.244	10914	2.212b		
BMI	Hypothesis	458.565	3	152.855	69.096	< 0.001
	Error	24144.244	10914	2.212b		
Child Sex	Hypothesis	729.411	1	729.411	329.718	< 0.001
	Error	24144.244	10914	2.212b		
FIT*	Hypothesis	4691.359	1	4691.359	2120.65	< 0.001
	Error	24144.244	10914	2.212b		
Birth Weight	Hypothesis	213.965	1	213.965	96.719	< 0.001
	Error	24144.244	10914	2.212b		
a .004 MS(B4) + .996 MS(Error)						
b MS(Error)						

Note: *FIT for child weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.224\ Child\ Age^{0.350}$$

Table 4.1.25 represents factor associated with child weight. When compared to children between the ages of 48 and 59 months, children under the age of 12 months (OR: 0.62, 95% CI: 0.46 – 0.84, $p < 0.05$) weigh 38% less. The weight of children between the ages of 12 and 23 months (OR: 0.46, 95% CI: 0.38 – 0.56, $p < 0.05$) is 54% lesser than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.46, 95% CI: 0.40 – 0.53, $p < 0.05$) weigh 54% lesser than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.65, 95% CI: 0.59 – 0.71, $p < 0.005$) weigh 35% less.

Children born in the first birth order (OR: 1.13, 95% CI: 1.04 – 1.23, $p < 0.05$) weigh more than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.08, 95% CI: 0.99 – 1.17, $p = 0.079$) weigh higher than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.00, 95% CI: 0.91 – 1.10, $p = 0.978$) weigh higher than children born in the 4 & above birth order.

Children's weight is 35% less in mothers with no education (OR: 0.65, 95% CI: 0.58 – 0.74, $p < 0.05$) compared to mothers with higher education. Children's weight is 29% less in mothers with primary education (OR: 0.71, 95% CI: 0.62 – 0.81, $p < 0.05$) compared to mothers with higher education. Children's weight is 20% less in mothers with secondary education (OR: 0.80, 95% CI: 0.72 – 0.90, $p < 0.05$) compared to mothers with higher education.

Children's weight is 5% less in mothers with no occupation (OR: 0.95, 95% CI: 0.87 – 1.03, $p = 0.183$) compared to agricultural mothers. As compared to agricultural mothers, the weight of children is 4% less in mothers with other occupations (OR: 0.96, 95% CI: 0.85 – 1.08, $p = 0.490$). As compared to rural region, the weight of children is 6% less in urban region (OR: 0.94, 95% CI: 0.87 – 1.02, $p = 0.155$).

Children in the poorest group (OR: 0.55, 95% CI: 0.49 – 0.62, $p < 0.05$) have 45% less weight than children in the richest group. Children in the poorer group (OR: 0.67, 95% CI: 0.60 – 0.76, $p < 0.05$) have 33% less weight than children in the richest group. Children in the middle group (OR: 0.71, 95% CI: 0.63 – 0.79, $p < 0.05$) have 29% less weight than children in the richest group. Children in the richer group (OR: 0.82, 95% CI: 0.73 – 0.92, $p < 0.05$) have 18% less weight than children in the richest group.

The weight of children with normal BMI (OR: 0.58, 95% CI: 0.47 – 0.72, $p < 0.05$) is 42% less than that of those with obese BMI. The weight of children with underweight BMI (OR: 0.43, 95% CI: 0.34 – 0.53, $p < 0.05$) is 57% lesser than that of children with obese BMI. The weight of children with overweight BMI (OR: 0.86, 95% CI: 0.71 – 1.12, $p = 0.328$) is 14% lesser than that of children with obese BMI. As compared to female children, weight of male children (OR: 1.68, 95% CI: 1.59 – 1.78, $p < 0.05$) is around 2 times higher.

Table 4.1.25: Factor Associated with Child Weight

Dependent variable: Child Weight					
Parameter	B	p - value	95% CI		OR (95% CI)
			LL	UL	
Child Age (Months)					
< 12	-0.475	0.002	-0.781	-0.17	0.62 (0.46, 0.84)
12 -23	-0.773	0.000	-0.969	-0.576	0.46 (0.38, 0.56)
24 - 35	-0.768	0.000	-0.904	-0.632	0.46 (0.40, 0.53)
36 - 47	-0.436	0.000	-0.535	-0.336	0.65 (0.59, 0.71)
48 – 59 *(Ref.)*	0				
Birth Order					
1	0.124	0.005	0.038	0.209	1.13 (1.04, 1.23)
2	0.076	0.079	-0.009	0.160	1.08 (0.99, 1.17)
3	0.001	0.978	-0.091	0.093	1.00 (0.91, 1.10)
4 & above *(Ref.)*	0				
Education Level					
No Education	-0.425	0.000	-0.55	-0.299	0.65 (0.58, 0.74)
Primary	-0.343	0.000	-0.473	-0.213	0.71 (0.62, 0.81)
Secondary	-0.222	0.000	-0.334	-0.110	0.80 (0.72, 0.90)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	-0.055	0.183	-0.135	0.026	0.95 (0.87, 1.03)
Others	-0.042	0.490	-0.162	0.078	0.96 (0.85, 1.08)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	-0.057	0.155	-0.135	0.021	0.94 (0.87, 1.02)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-0.597	0.000	-0.72	-0.474	0.55 (0.49, 0.62)
Poorer	-0.399	0.000	-0.517	-0.281	0.67 (0.60, 0.76)
Middle	-0.348	0.000	-0.465	-0.231	0.71 (0.63, 0.79)
Richer	-0.202	0.001	-0.317	-0.087	0.82 (0.73, 0.92)
Richest *(Ref.)*	0				
BMI					
Normal	-0.542	0.000	-0.753	-0.33	0.58 (0.47, 0.72)
Underweight	-0.855	0.000	-1.072	-0.637	0.43 (0.34, 0.53)
Overweight	-0.113	0.328	-0.338	0.113	0.89 (0.71, 1.12)
Obese *(Ref.)*	0				
Child Sex					
Male	0.518	0.000	0.462	0.574	1.68 (1.59, 1.78)
Female *(Ref.)*	0				
FIT*	0.998	0.000	0.956	1.041	2.71 (2.60, 2.83)
Birth Weight	0.425	0.000	0.34	0.51	1.53 (1.40, 1.67)

Note: *FIT for child weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.224\ Child\ Age^{0.350}$$

Table 4.1.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in less than 12 months age group is around 10.5 kg. The mean weight of a child in 12 - 23 months and 24 - 35 months age group is around 10.2 kg. The mean weight of a child in 36 - 47 months age group is around 10.5 kg. The mean weight of a child in 48 - 59 months age group is around 10.9 kg.

Table 4.1.26: Descriptive statistics of Child Weight by child age

Dependent variable: Child Weight				
Child Age (Month)	Mean	Std. Error	95% CI	
			LL	UL
< 12	10.49	0.10	10.30	10.68
12 - 23	10.19	0.05	10.09	10.29
24 - 35	10.20	0.05	10.10	10.29
36 - 47	10.53	0.06	10.41	10.64
48 - 59	10.96	0.08	10.81	11.12

Table 4.1.27 represents a pairwise comparison of child weight by child age. Mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.297, 95% CI: 0.15 to 0.45, $p < 0.05$), between less than 12 months and 24 - 35 months age group (M D = 0.293, 95% CI: 0.08 to 0.50, $p < 0.05$) and between less than 12 months and 48 - 59 months age group (M D = -0.475, 95% CI: -0.78 to -0.17, $p < 0.05$) is statistically significant. Mean difference of child weight between 12 – 23 months and 36 - 47 months age group (M D = -0.337, 95% CI: -0.49 to -0.18, $p < 0.05$), between 12 – 23 months and 48 - 59 months age group (M D = -0.773, 95% CI: -0.97 to -0.58, $p < 0.05$) is statistically significant. Mean difference of child weight between 24 - 35 months and 36 - 47 months age group (M D = -0.332, 95% CI: - 0.44 to - 0.23, $p < 0.05$), between 24 - 35 months and 48 - 59 months age group (M D = -0.768, 95% CI: -0.90 to -0.63, $p < 0.05$) is statistically significant. Mean difference of child weight between 36 - 47 months and 48 - 59 months age group (M D = -0.436, 95% CI: - 0.54 to - 0.34, $p < 0.05$) is statistically significant.

Table 4.1.27: Pairwise comparison of Child Weight by child age

Dependent variable: Child Weight						
Child Age (Months)	Child Age (Months)	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
< 12	12 - 23	0.297*	0.08	0.000	0.15	0.45
	24 - 35	0.293*	0.11	0.006	0.08	0.50
	36 - 47	- 0.039	0.13	0.766	-0.30	0.22
	48 - 59	- 0.475*	0.16	0.002	-0.78	-0.17
12 - 23	24 - 35	- 0.005	0.06	0.934	-0.12	0.11
	36 - 47	- 0.337*	0.08	0.000	-0.49	-0.18
	48 - 59	- 0.773*	0.10	0.000	-0.97	-0.58
24 - 35	36 - 47	- 0.332*	0.05	0.000	-0.44	-0.23
	48 - 59	- 0.768*	0.07	0.000	-0.90	-0.63
36 - 47	48 - 59	- 0.436*	0.05	0.000	-0.54	-0.34
* Mean difference is significant at the 0.05 level.						

Table 4.1.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in first birth order is around 10.5 kg. The mean weight of a child in second and third birth order is around 10.4 kg. The mean weight of a child in 4 & above is around 10.4 kg.

Table 4.1.28: Descriptive statistics of Child Weight by birth order

Dependent variable: Child Weight				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	10.545	0.042	10.463	10.628
2	10.498	0.042	10.416	10.579
3	10.423	0.047	10.331	10.515
4 & above	10.422	0.047	10.331	10.513

Table 4.1.29 represents a pairwise comparison of child weight by birth order. Mean difference of child weight between first and second birth order (M D = 0.048, 95% CI: -0.024 to 0.119, p = 0.048) is statistically insignificant. Mean difference of child weight between first and second birth order (M D = 0.122, 95% CI: 0.037 to 0.207, $p < 0.05$) and between first and 4 & above birth order (M D = 0.124, 95% CI: 0.038 to 0.209, $p < 0.05$) is statistically significant. Mean difference of child weight between second and third birth order (M D = 0.074, 95% CI: -0.011 to 0.159, p = 0.086) and between second and 4 & above birth order (M D = 0.076, 95% CI: -0.009

to 0.160, p = 0.079) is statistically insignificant. Mean difference of child weight between third and 4 & above birth order (M D = 0.001, 95% CI: -0.091 to 0.093, p = 0.978) is statistically insignificant.

Table 4.1.29: Pairwise comparison of Child Weight by birth order

Dependent variable: Child Weight						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
1	2	0.048	0.036	0.189	-0.024	0.119
	3	0.122*	0.043	0.005	0.037	0.207
	4 & above	0.124*	0.043	0.005	0.038	0.209
2	3	0.074	0.043	0.086	-0.011	0.159
	4 & above	0.076	0.043	0.079	-0.009	0.160
3	4 & above	0.001	0.047	0.978	-0.091	0.093
*Mean difference is significant at the 0.05 level.						

Table 4.1.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 10.2 kg. For mothers with primary education, average weight of the child is around 10.3 kg. For mothers with secondary education, average weight of the child is around 10.4 kg. Similarly, for mothers with higher education, the average child's weight is around 10.7 kg.

Table 4.1.30: Descriptive statistics of Child Weight by educational level

Dependent variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	10.295	0.042	10.213	10.376
Primary	10.377	0.048	10.283	10.470
Secondary	10.498	0.040	10.419	10.576
Higher	10.719	0.061	10.600	10.839

Table 4.1.31 represents a pairwise comparison of child weight by educational level. Mean difference of child weight between mothers with no education and primary (M D = - 0.082, 95% CI: - 0.167 to -0.003, p = 0.059) is statistically insignificant. Mean difference of child weight between mothers with no education and

secondary education (M D = -0.203, 95% CI: -0.277 to -0.129, $p < 0.05$), between mothers with no education and higher education level (M D = -0.425, 95% CI: -0.550 to -0.299, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with primary and secondary education (M D = -0.121, 95% CI: -0.206 to -0.037, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with primary and higher education (M D = -0.343, 95% CI: -0.473 to -0.213, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = 0.222, 95% CI: -0.334 to -0.110, $p < 0.05$) is statistically significant.

Table 4.1.31: Pairwise comparisons of Child Weight by educational level

Dependent variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No education	Primary	-0.082	0.043	0.059	-0.167	0.003
	Secondary	-0.203*	0.038	0.000	-0.277	-0.129
	Higher	-0.425*	0.064	0.000	-0.55	-0.299
Primary	Secondary	-0.121*	0.043	0.005	-0.206	-0.037
	Higher	-0.343*	0.066	0.000	-0.473	-0.213
Secondary	Higher	-0.222*	0.057	0.000	-0.334	-0.11
*Mean difference is significant at the .05 level.						

Table 4.1.32 represents the descriptive statistics of child weight by respondent occupation. Mean weight of the child for mothers with no occupation is around 10.4 kg. But, for mothers with other occupation and agricultural mothers, average weight of the child is around 10.5 kg.

Table 4.1.32: Descriptive statistics of Child Weight by respondent occupation

Dependent variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	10.450	0.033	10.385	10.514
Others	10.462	0.056	10.353	10.571
Agriculture	10.504	0.049	10.409	10.600

Table 4.1.33 represents a pairwise comparison of child weight by respondent occupation. Mean difference of child weight between mothers with no occupation and mothers with other occupation (M D = -0.012, 95% CI: -0.113 to 0.088, p = 0.809), between mothers with no occupation and agricultural mothers (M D = -0.055, 95% CI: -0.135 to 0.026, p = 0.183) is statistically insignificant. Similarly, mean difference of child weight between mothers with other occupation and agricultural mothers (M D = -0.042, 95% CI: -0.162 to 0.078, p = 0.490) is statistically insignificant.

Table 4.1.33: Pairwise comparisons of Child Weight by respondent occupation

Dependent variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No Occupation	Others	-0.012	0.051	0.809	-0.113	0.088
	Agriculture	-0.055	0.041	0.183	-0.135	0.026
Others	Agriculture	-0.042	0.061	0.49	-0.162	0.078

Table 4.1.34 represents the descriptive statistics of child weight by type of residence. Mean weight of child in urban as well as rural regions is around 10.5 kg and 10.4 kg, respectively.

Table 4.1.34: Descriptive statistics of Child Weight by type of residence

Dependent variable: Child Weight				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Rural	10.50	0.038	10.426	10.575
Urban	10.44	0.044	10.358	10.53

Table 4.1.35 represents a pairwise comparison of child weight by type of residence. Mean difference of child weight between rural region and urban region (M D = 0.057, 95% CI: -0.021 to 0.135, p = 0.155) is statistically insignificant.

Table 4.1.35: Pairwise comparisons of Child Weight by type of residence

Dependent variable: Child Weight						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Rural	Urban	0.057	0.04	0.155	-0.021	0.135

Table 4.1.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.2 kg. In the poorer groups, children's average weight is around 10.4 kg. In the middle groups, children's average weight is around 10.4 kg. Similarly, in richer and richest groups, the average weight of children is around 10.6 kg and 10.8 kg, respectively.

Table 4.1.36: Descriptive statistics of Child Weight by wealth index

Dependent variable: Child Weight				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.184	0.047	10.091	10.277
Poorer	10.382	0.047	10.290	10.474
Middle	10.433	0.049	10.337	10.529
Richer	10.579	0.051	10.480	10.679
Richest	10.781	0.052	10.679	10.883

Table 4.1.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest and poorer group (M D = -0.198, 95% CI: - 0.275 to - 0.121, $p < 0.05$), between poorest group and middle group

(M D = - 0.249, 95% CI: - 0.338 to - 0.159, $p < 0.05$), between poorest group and richer group (M D = - 0.395, 95% CI: - 0.499 to - 0.291, $p < 0.05$), and between poorest group and richest group (M D = - 0.597, 95% CI: - 0.720 to - 0.474, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and middle group (M D = - 0.051, 95% CI: - 0.140 to – 0.039, $p = 0.265$) is statistically insignificant. Mean difference of child weight between poorer group and richer group (M D = - 0.197, 95% CI: -0.299 to – 0.096, $p < 0.05$), and between poorer group and richest group (M D = - 0.399, 95% CI: - 0.517 to – 0.281, $p < 0.05$) is statistically significantly. Mean difference of child weight between middle and richer group (M D = - 0.146, 95% CI: - 0.250 to – 0.042, $p < 0.05$) and between middle and richest group (M D = - 0.348, 95% CI: - 0.465 to – 0.231, $p < 0.05$) is statistically significant. Mean difference of child weight between richer and richest group (M D = - 0.202, 95% CI: - 0.317 to – 0.087, $p < 0.05$) is statistically significant.

Table 4.1.37: Pairwise comparisons of Child Weight by wealth index

Dependent variable: Child Weight						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Poorest	Poorer	-0.198*	0.039	0.000	-0.275	-0.121
	Middle	-0.249*	0.046	0.000	-0.338	-0.159
	Richer	-0.395*	0.053	0.000	-0.499	-0.291
	Richest	-0.597*	0.063	0.000	-0.72	-0.474
Poorer	Middle	-0.051	0.046	0.265	-0.14	0.039
	Richer	-0.197*	0.052	0.000	-0.299	-0.096
	Richest	-0.399*	0.06	0.000	-0.517	-0.281
Middle	Richer	-0.146*	0.053	0.006	-0.25	-0.042
	Richest	-0.348*	0.06	0.000	-0.465	-0.231
Richer	Richest	-0.202*	0.059	0.001	-0.317	-0.087
*Mean difference is significant at the 0.05 level.						

Table 4.1.38 represents the descriptive statistics of Child Weight by BMI. The average weight of a child with a normal BMI is around 10.3 kg. The average weight of child with underweight BMI is around 9.9 kg. The average weight of a child with an overweight BMI is around 10.7 kg. Similarly, children's average weight in obese BMI is around 10.8 kg.

Table 4.1.38: Descriptive statistics of Child Weight by BMI

Dependent variable: Child Weight				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	10.308	0.028	10.253	10.362
Underweight	9.995	0.036	9.924	10.065
Overweight	10.737	0.051	10.636	10.837
Obese	10.849	0.107	10.639	11.06

Table 4.1.39 represents a pairwise comparison of child weight by BMI. Mean difference of child weight between normal BMI and underweight BMI (M D = 0.313, 95% CI: 0.247 to 0.379, $p < 0.05$), between normal BMI and overweight BMI (M D = - 0.429, 95% CI: - 0.530 to - 0.328, $p < 0.05$) is statistically significant. Also, mean difference of child weight between normal BMI and obese BMI (M D = - 0.542, 95% CI: - 0.753 to - 0.330, $p < 0.05$) is statistically significant. Mean difference of child weight between underweight BMI and overweight BMI (M D = - 0.742, 95% CI: - 0.854 to - 0.630, $p < 0.05$) and between underweight BMI and obese BMI (M D = - 0.855, 95% CI: -1.072 to -0.637, $p < 0.05$) is statistically significant. Mean difference of child weight between overweight BMI and obese BMI (M D = -0.113, 95% CI: - 0.338 to 0.113, $p = 0.328$) is statistically insignificant.

Table 4.1.39: Pairwise comparisons of Child Weight by BMI

Dependent variable: Child Weight						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Normal	Underweight	0.313*	0.034	0.000	0.247	0.379
	Overweight	-0.429*	0.052	0.000	-0.53	-0.328
	Obese	-0.542*	0.108	0.000	-0.753	-0.33
Underweight	Overweight	-0.742*	0.057	0.000	-0.854	-0.63
	Obese	-0.855*	0.111	0.000	-1.072	-0.637
Overweight	Obese	-0.113	0.115	0.328	-0.338	0.113
*Mean difference is significant at the 0.05 level.						

Table 4.1.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 10.7 kg. Similarly, children's average weight in females is around 10.2 kg.

Table 4.1.40: Descriptive statistics of Child Weight by child sex

Dependent variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	10.731	0.038	10.6565	10.806
Female	10.213	0.039	10.137	10.289

Table 4.1.41 represents a pairwise comparison of child weight by Child Sex. Mean difference of child weight between in female and male children (M D = -0.518, 95% CI: -0.574 to -0.462, $p < 0.05$) is statistically significant.

Table 4.1.41: Pairwise comparisons of Child Weight by child sex

Dependent variable: Child Weight						
Sex of child	Sex of child	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Female	Male	-0.518*	0.029	0.000	-0.574	-0.462
*Mean difference is significant at the 0.05 level.						

4.1.7 Growth Nomograms

Birth-Weight by Socio-Demographic Characteristics

Table 4.1.42 shows the distribution of under-5 children by their birth-weight categories and socio-demographic characteristics in the Central Region. Distribution of under-5 children by their age & birth weight showed that 3.2% - 4.4% children had their birthweight below 2000 gm, 7.8% - 10.6% of children had their birth weight between 2000 gm – 2499 gm, 18.4% - 23.5% children had their birth-weight between 2500 gm – 2999 gm and 61.0% - 70.6% children had their birth-weight either 3000 gm or more. A significant association $\left(\chi^2_{d.f.=12} = 330.57,\ p < 0.001\right)$ was observed between age of the children and their birth weight. Also, a greater number of boys (67.2%) had their birth-weight of 3000 gm or more, than the girls (65.6%). Similarly, higher number of girls had their birth weight less than 3000 gm than boys. Like age, sex was also found to be significantly associated $\left(\chi^2_{df=3} = 33.23, p < 0.001\right)$ with the birth weight of the under-5 children.

Considering birth order, more children with higher birth order had birth weight of 3000 gm or above, and consequently, a fewer number of children with higher birth order had their birth weight less than 3000 gm. Like age & sex, a significant association $\left(\chi^2_{df=9} = 1359.27,\ p < 0.001\right)$ of birth order was also observed with a birth weight of the under-5 children. For Body Mass Index (BMI), 3.9% - 4.5% of under-5 children with different BMI scores had their birth weight below 2000 gm; 8.4% - 10% gm of the children had their birth weight between 2000 gm and 2499 gm; 18.9% - 21.1% of the children had their birth weight between 2500 gm and 2999 gm. In these birth weight categories, percentage of children decreased as the BMI scores increased. Further, almost 64% - 68% of the children belonged to the birth weight category 3000 gm & above. Also, the percentage of children increased with increasing BMI scores. BMI was also found to be significantly associated $\left(\chi^2_{df=9} = 68.09, d.f. = 9, p < 0.001\right)$ with a birth weight of the under-5 children.

Considering mother's highest education level, 3.3% - 4.8% of the under-5 children had their birth weight below 2000 gm; 8.0% - 10.3% of the children had their birth weight ranging from 2000 gm to 2499 gm; 14.9% - 27.5% children had their birth-weight between 2500 gm and 2999 gm and 59.0% - 73.8% children had their birth-weight of 3000 gm & above. Further, for children having their birth weight below 3000 gm, the percentage of children - belonging to different mothers' highest education level categories, decreased as their education level increased. The situation was just reverse for children with a birth-weight 3000 gm & more. There was a significant association $\left(\chi^2_{df=9} = 1412.42,\ p < 0.001\right)$ between children's birth weight and mother's highest level of education. Furthermore, when the mother's occupation was considered with under-5 children's birth weight, the analysis showed that mother's occupation was not significantly associated $\left(\chi^2_{df=9} = 15.95, p = 0.07\right)$ with the children's birth weight.

The analysis further revealed that respondents' two factors – place of residence as well as wealth index also played important role in the determination of their birth weight. Findings showed that 4.9% of urban and 3.8% of rural under-5 children had their birth weight below 2000 gm. For birth-weight groups, 2000 gm – 2499 gm and 2500 gm – 2999 gm, the percentage of under 5 children was more for the urban area than for rural areas. However, for the birth-weight group 3000 gm & above, the situation was just reverse. Place of residence of children was significantly associated $\left(\chi^2_{df=3} = 287.69,\ p < 0.001\right)$ with their birth weight. For the wealth index also, our analysis revealed almost similar trend. The percentage of under-5 children in various wealth index categories increased with an increase in their wealth status for all the birth-weight categories below 3000 gm. However, this trend was reversed for the birth-weight category 3000 gm & above, i.e., the percentage of children in various wealth index categories decreased with an increase in their wealth index. A significant association $\left(\chi^2_{df=12} = 789.23,\ p < 0.001\right)$ was seen between the wealth index of under-5 children and their birth weight.

Table 4.1.42: Birth-weight categories of under-5 children by their socio-demographic characteristics in Central Region of India: National Family Health Survey – 4 (2015 – 16)

Socio-demographic Characteristics		Birth-weight (gm)								
		< 2000		2000 – 2499		2500 - 2999		3000+		Total
		n_1	%	n_2	%	n_3	%	n_4	%	n
Child Age (Months)		Chi-square (d.f. = 12) = 330.567, p = 0.000								
	< 12	619	4.0	1634	10.6	3627	23.5	9564	61.9	15444
	12 -23	555	4.4	1216	9.6	2806	22.3	8033	63.7	12610
	24 - 35	528	3.8	1293	9.4	2915	21.2	8992	65.5	13728
	36 - 47	478	3.3	1313	9.2	2737	19.1	9796	68.4	14324
	48 - 59	444	3.2	1103	7.8	2591	18.4	9939	70.6	14077
Sex of Child		Chi-square (d.f. = 3) = 33.234, p = 0.000								
	Boys	1505	3.8	3517	8.9	7938	20.1	26567	67.2	39527
	Girls	1556	4.3	3501	9.7	7376	20.4	23685	65.6	36118
Birth Order		Chi-square (d.f. = 9) = 1359.274, p = 0.000								
	1	1312	5.2	2780	10.9	6052	23.8	15265	60.1	25409
	2	868	4.0	2039	9.3	4876	22.3	14131	64.5	21914
	3	416	3.2	1105	8.6	2372	18.4	9026	69.9	12919
	4 & above	465	3.0	1094	7.1	2014	13.1	11830	76.8	15403
BMI (Kg/m^2)		Chi-square (d.f. = 9) = 68.093, p = 0.000								
	< 18.5	883	4.5	1961	10.0	4135	21.1	12593	64.3	19572
	18.5 -24.9	1792	3.8	4255	9.0	9457	20.1	31515	67.0	47019
	25.0 - 29.9	295	4.3	594	8.7	1286	18.9	4622	68.0	6797
	≥ 30	62	3.9	132	8.4	327	20.7	1058	67.0	1579
Educational Level		Chi-square (d.f. = 9) = 1412.418, p = 0.000								
	No Education	966	3.3	2332	8.0	4325	14.9	21456	73.8	29079
	Primary	519	4.1	1223	9.8	2483	19.8	8285	66.2	12510
	Secondary	1321	4.8	2856	10.3	6752	24.4	16747	60.5	27676
	Higher	255	4.0	607	9.5	1754	27.5	3764	59.0	6380
Respondent's Occupation		Chi-square (d.f. = 9) = 15.946, p = 0.068								
	No Occupation	387	4.3	795	8.8	1823	20.3	5994	66.6	8999
	Others	55	5.2	80	7.6	234	22.1	690	65.2	1059
	Agriculture	78	4.0	171	8.8	382	19.6	1318	67.6	1949
	Do not know	1	1.0	5	4.8	31	29.5	68	64.8	105
Type of Residence		Chi-square (d.f. = 3) = 287.694, p = 0.000								
	Urban	847	4.9	1768	10.3	4070	23.7	10521	61.1	17206
	Rural	2214	3.8	5250	9.0	11244	19.2	39731	68.0	58439
Wealth Index		Chi-square (d.f. = 12) = 789.226, p = 0.000								
	Poorest	841	3.3	2120	8.3	4224	16.6	18218	71.7	25403
	Poorer	738	4.1	1664	9.1	3602	19.8	12194	67.0	18198
	Middle	550	4.3	1264	9.9	2654	20.8	8276	64.9	12744
	Richer	506	4.9	1037	10.1	2380	23.1	6362	61.9	10285
	Richest	426	4.7	933	10.3	2454	27.2	5202	57.7	9015

4.1.7.1 Estimation of Growth Dynamics of Under-5 Children Using Statistical Models

All 11 of the afore mentioned statistical models (Chapter 2) were fitted to height and weight data of children under the age of 5, to estimate the growth curves, considering ages (months) of each child for each of their four birth-weight categories separately. Applying the above-mentioned criteria for the models' best fit, our analysis revealed that only two statistical models namely *Cubic Model* and *Power Model*, provided best fit for height and weight data of children under the age of 5, who fell into various birth-weight categories, allowing us to estimate the growth of boys and girls separately. Here, results of 2 best-fit models are shown below in Table 4.1.43 & Table 4.1.44.

Table 4.1.43 describes models – summary for estimating the height of boys & girls separately by birth weight. Here, for a height of the boys, considering the Coefficient of Determinant (R^2) as the criterion for the best fit, *Cubic Model* fitted best for the birth-weight group 2500 gm – 2999 gm ($R^2 = 0.832$), followed by the group < 2000 gm ($R^2 = 0.811$), group 2000 gm – 2499 gm ($R^2 = 0.802$), and then, birth-weight group 3000 gm and above ($R^2 = 0.796$). For the height of girls, however, *Power Model* showed the best fit for the birth-weight group < 2000 gm ($R^2 = 0.817$) but for the rest of the 3 birth-weight groups, *Cubic Model* was the best-fitted model. Thus, as per the Coefficient of Determinants (R^2), *Cubic Model* showed best fit ($R^2 = 0.826$) for birth-weight group 2500 – 2999 gm, followed by the group 2000 – 2499 gm ($R^2 = 0.811$) and the group 3000 gm & above ($R^2 = 0.790$).

Table 4.1.44 describes models – summary for estimating the weight of boys & girls separately by birth weight. For the weight of the boys & girls, the best-fitted model was *Power Model*. Further, considering boys, as per the Coefficient of Determinants

(R^2), this model fitted best for the birth-weight group 2500 – 2999 gm ($R^2 = 0.811$), followed by the group 2000 – 2499 gm ($R^2 = 0.789$), group < 2000 gm ($R^2 = 0.778$) and the birth-weight group 3000 gm & above ($R^2 = 0.763$). For estimating the weight of the girls, the *Power Model* showed the best fit for the birth-weight group 2500 – 2999 gm ($R^2 = 0.816$), followed by the group < 2000 gm ($R^2 = 0.803$), group 2000 – 2499 gm ($R^2 = 0.793$) and then, birth-weight group 3000 gm & above ($R^2 = 0.771$).

Table 4.1.43: Models' summary for height of boys & girls by birth-weight categories

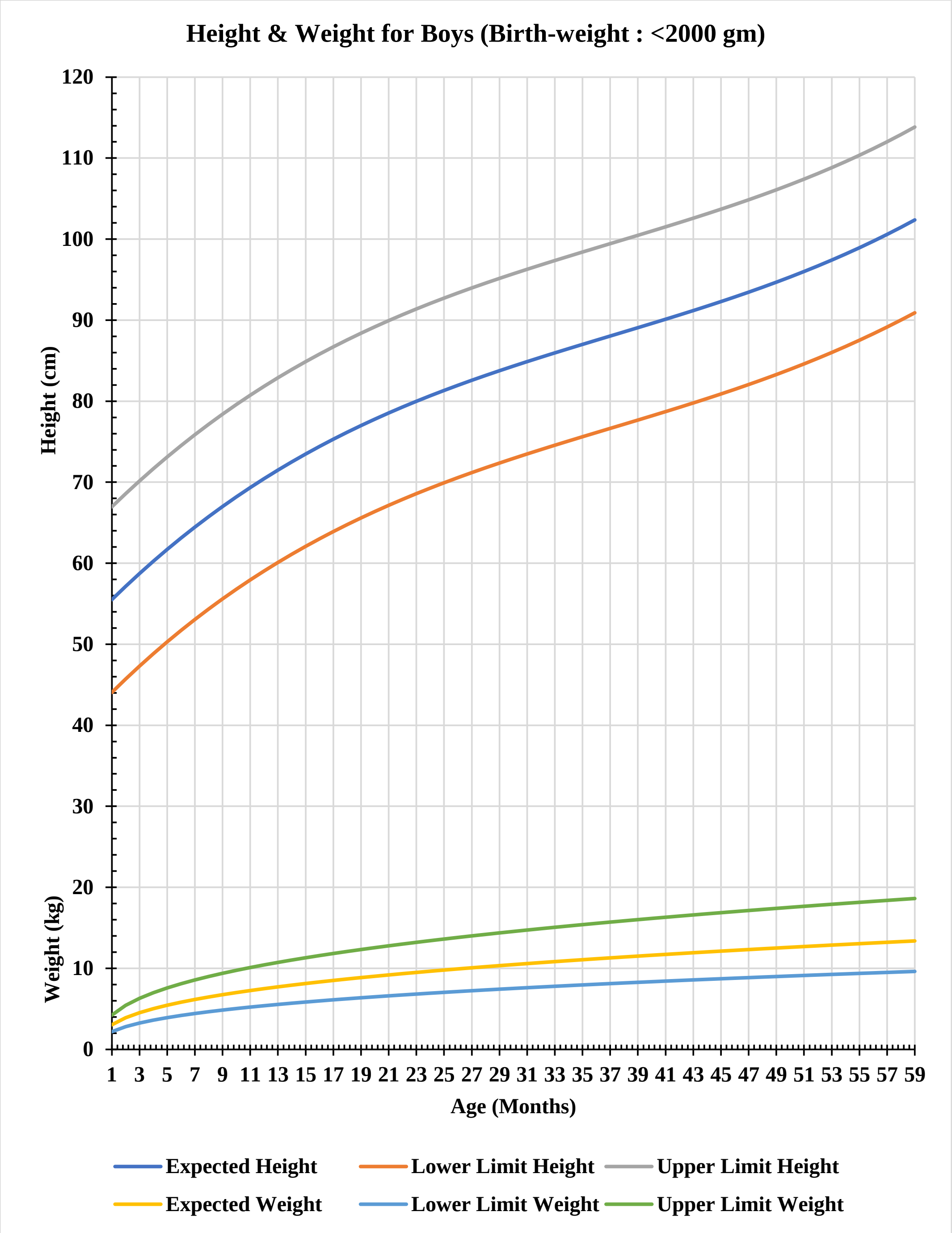
Birth – weight (gm)	**Model**	**R^2**	**Constant**	**d. f.**		**F**	**b_1**	**b_2**	**b_3**
				Regression	**Residual**				
Boys									
< 2000	Cubic	0.811	53.795	3	1235	1771.2	1.739	-0.033	0.0002
2000 – 2499	Cubic	0.802	54.524	3	3167	4273.4	1.691	-0.03	0.0002
2500 – 2999	Cubic	0.832	55.124	3	7406	12256.2	1.667	-0.028	0.0002
3000 +	Cubic	0.796	56.014	3	23945	31147.4	1.602	-0.027	0.0002
Girls									
< 2000	Power	0.817	44.612	1	1324	5891.8	0.186	---	---
2000 –2499	Cubic	0.811	54.254	3	3193	4558.7	1.555	-0.025	0.0002
2500 – 2999	Cubic	0.826	53.445	3	6895	10877.7	1.763	-0.033	0.0002
3000 +	Cubic	0.79	55.051	3	21147	26445.0	1.53	-0.024	0.0001

Table 4.1.44: Models' summary for weight (kg) of boys & girls by birth-weight categories

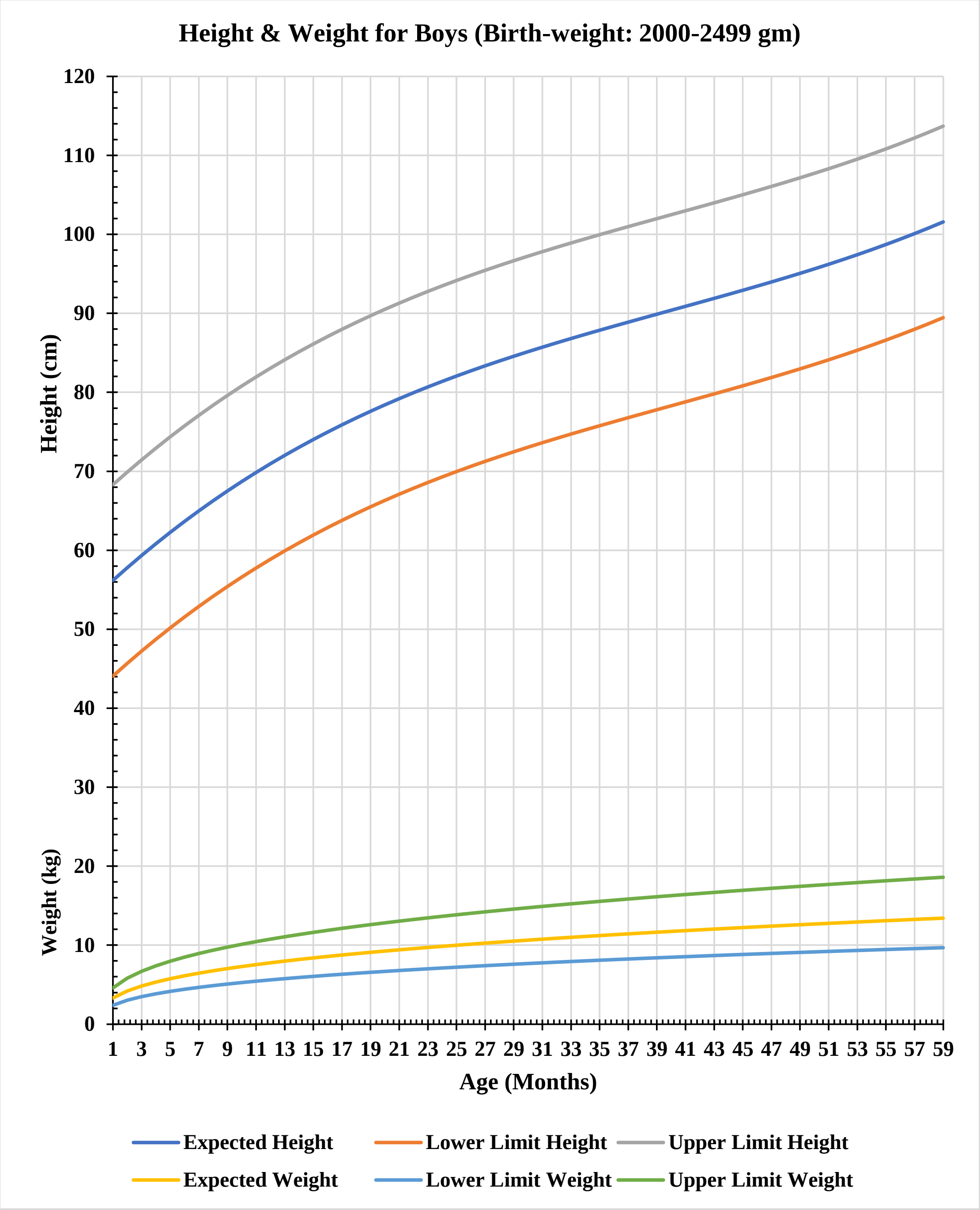
Birth-weight (gm)	**Model**	**R^2**	**Constant**	**d. f.**		**F**	**b_1**
Boys				**Regression**	**Residual**		
< 2000	Power	0.778	3030.168	1	1237	4323.3	0.364
2000 - 2499	Power	0.789	3306.981	1	3172	11895.3	0.343
2500 - 2999	Power	0.811	3485.011	1	7414	31890.8	0.333
3000 +	Power	0.763	3646.12	1	23975	77292.8	0.325
Girls							
< 2000	Power	0.803	2641.494	1	1325	5394.6	0.389
2000 - 2499	Power	0.793	3133.014	1	3198	12362.1	0.345
2500 - 2999	Power	0.816	3202.653	1	6899	30568.7	0.346
3000 +	Power	0.771	336.144	1	21168	71163.55	0.337

4.1.7.2 Estimation of Height & Weight of Under 5 Children for Different Birth-Weight Categories

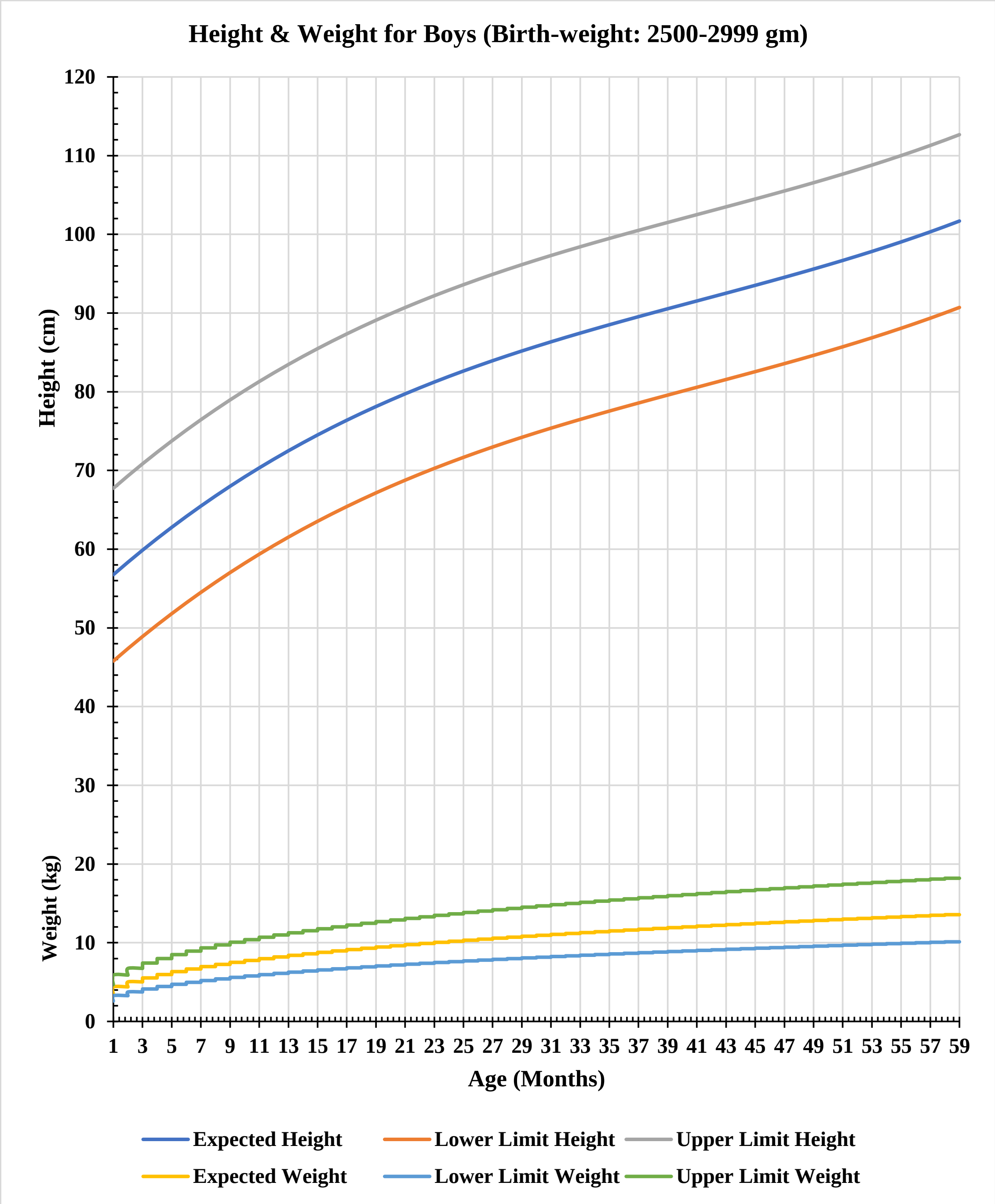
We estimated growth values – considering height and weight of under-5 children for their ages – ranging from 1 to 59 months, considering all 4 birth-weight groups, viz., < 2000 gm, 2000 – 2499 gm, 2500 – 2999 gm & 3000 gm & above, by using *Cubic Model* or *Power Model* whichever fitted best under the situation, for boys and girls separately. Therefore, growth charts – in terms of height and weight curves, were drawn for each of the birth-weight group for two sexes separately. Estimated average height and weight curves for boys are shown in *Figures 4.1.5(a) to 4.1.5(d)* for each of the 4 birthweights separately. Similarly, such estimated average height and weight curves for girls for all four birth-weight groups are shown in *Figures 4.1.6(a) to 4.1.6 (d).* The graphs shown here, besides giving estimated mean height and mean weight curves in each case, also give curves for 95% upper as well as lower confidence limits. As a result, it is possible to determine not only the projected growth values of under-5 children in terms of their average height and weight for their ages (months) in each case, but also their 95 % confidence limits, using the curves provided in *Figures 4.1.5(a) to 4.1.5(d) and Figure 4.1.6(a) to 4.1.6(d).*



$Figure$ 4.1.5(a): NFHS-4 (Birth-weight <2000 gm): Estimated height and weight curves for boys of Central Region (India), using Cubic and Power Models respectively



$Figure$ 4.1.5(b): NFHS-4 (Birth-weight 2000 – 2499 gm): Estimated height and weight curves for boys of Central Region (India), using Cubic and Power Models respectively



$Figure$ 4.1.5(c): NFHS-4 (Birth-weight 2500 – 2999 gm): Estimated height and weight curves for boys of Central Region (India), using Cubic and Power Models respectively

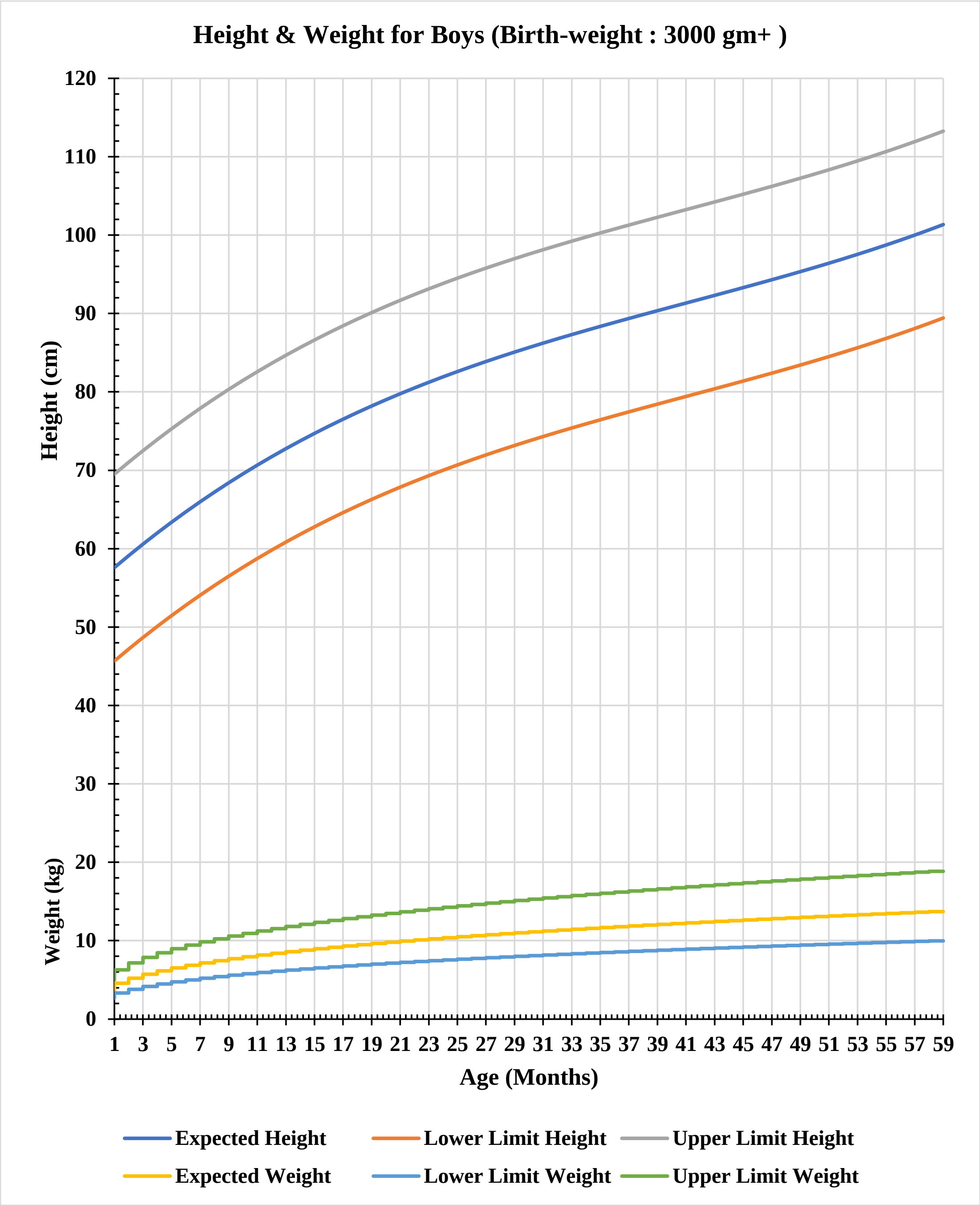
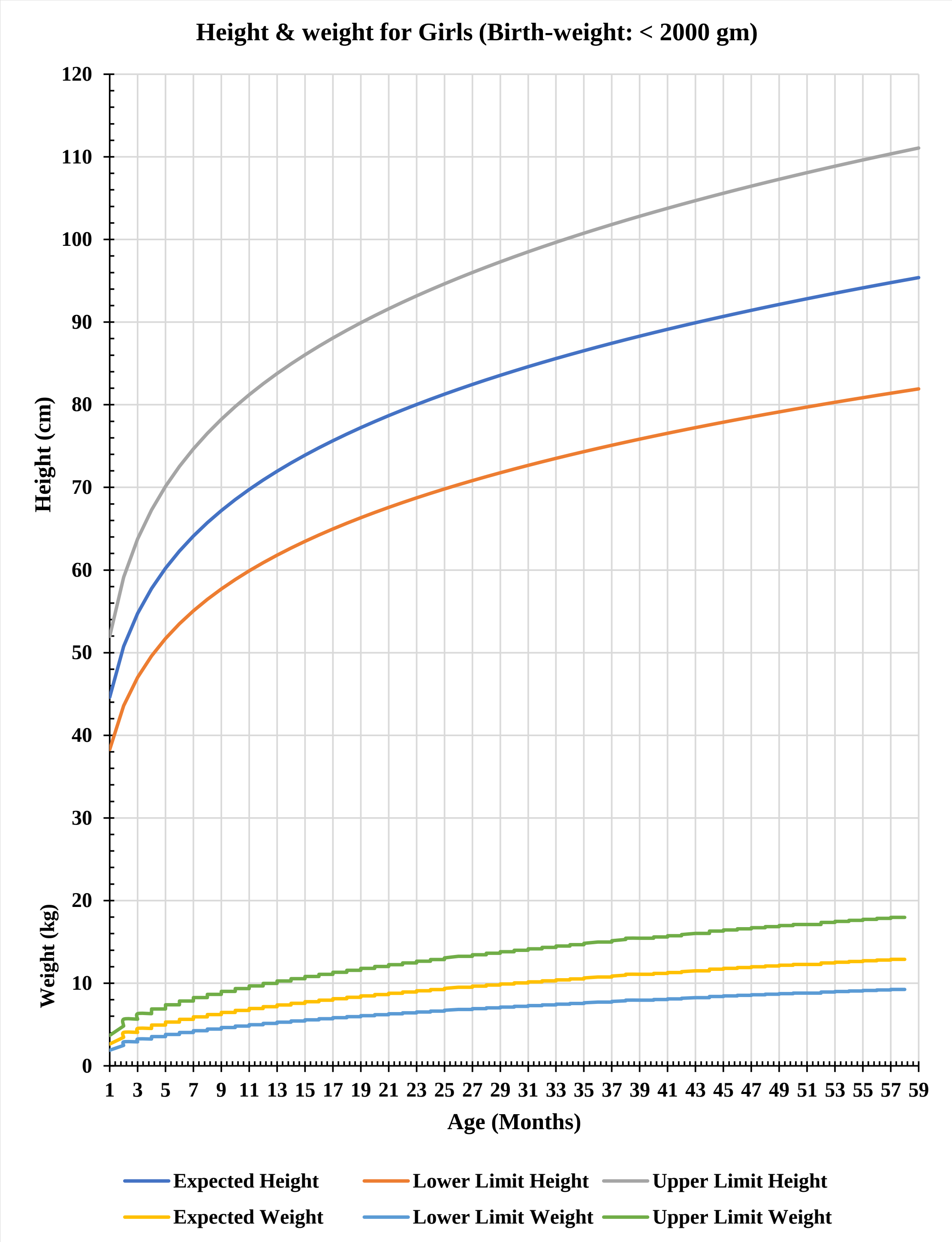


Figure 4.1.5(*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated height and weight curves for boys of Central Region (India), using Cubic and Power Models respectively



$Figure$ 4.1.6(a): NFHS-4 (Birth-weight < 2000 gm): Estimated height and weight curves for girls of Central Region (India), Using Power Model

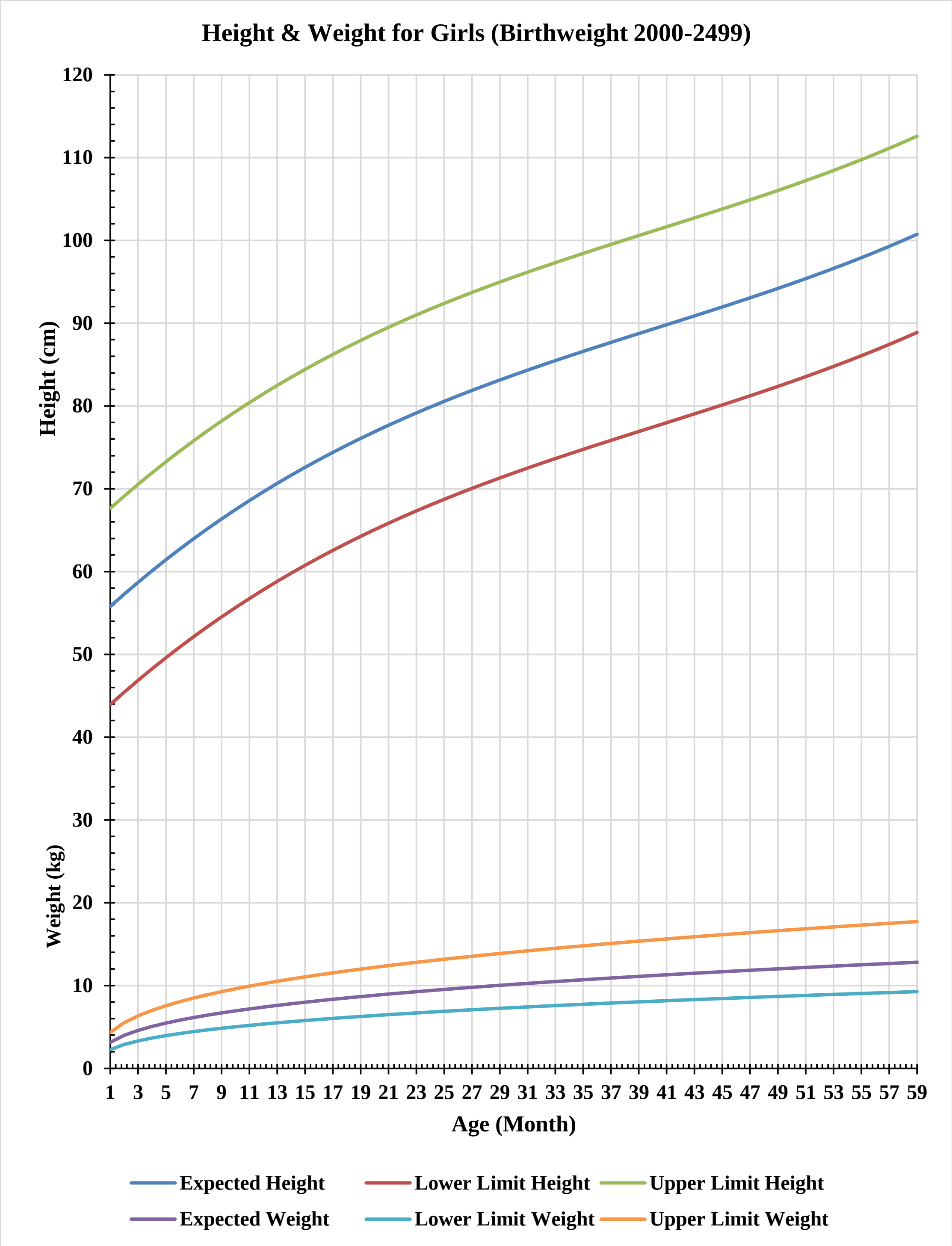
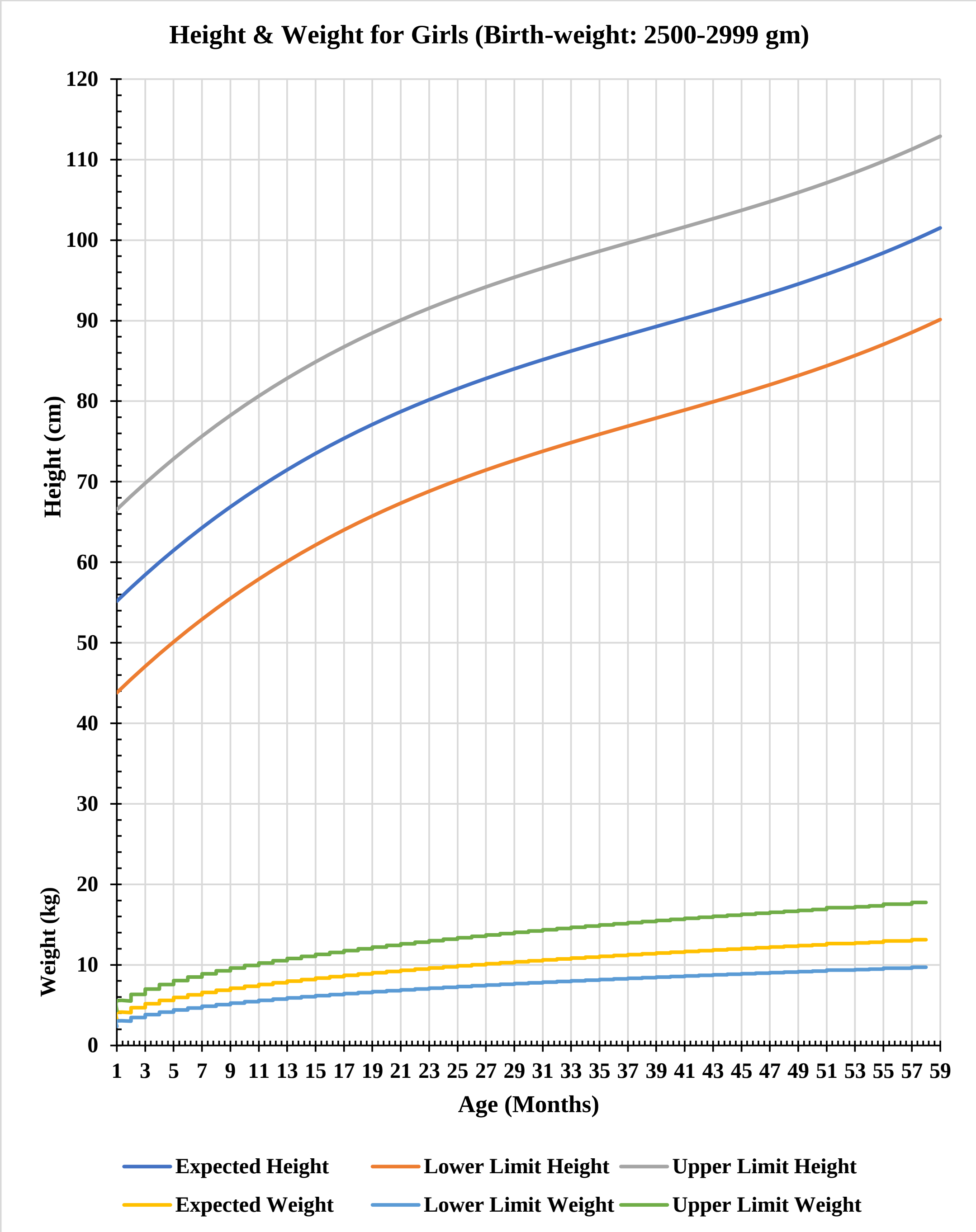
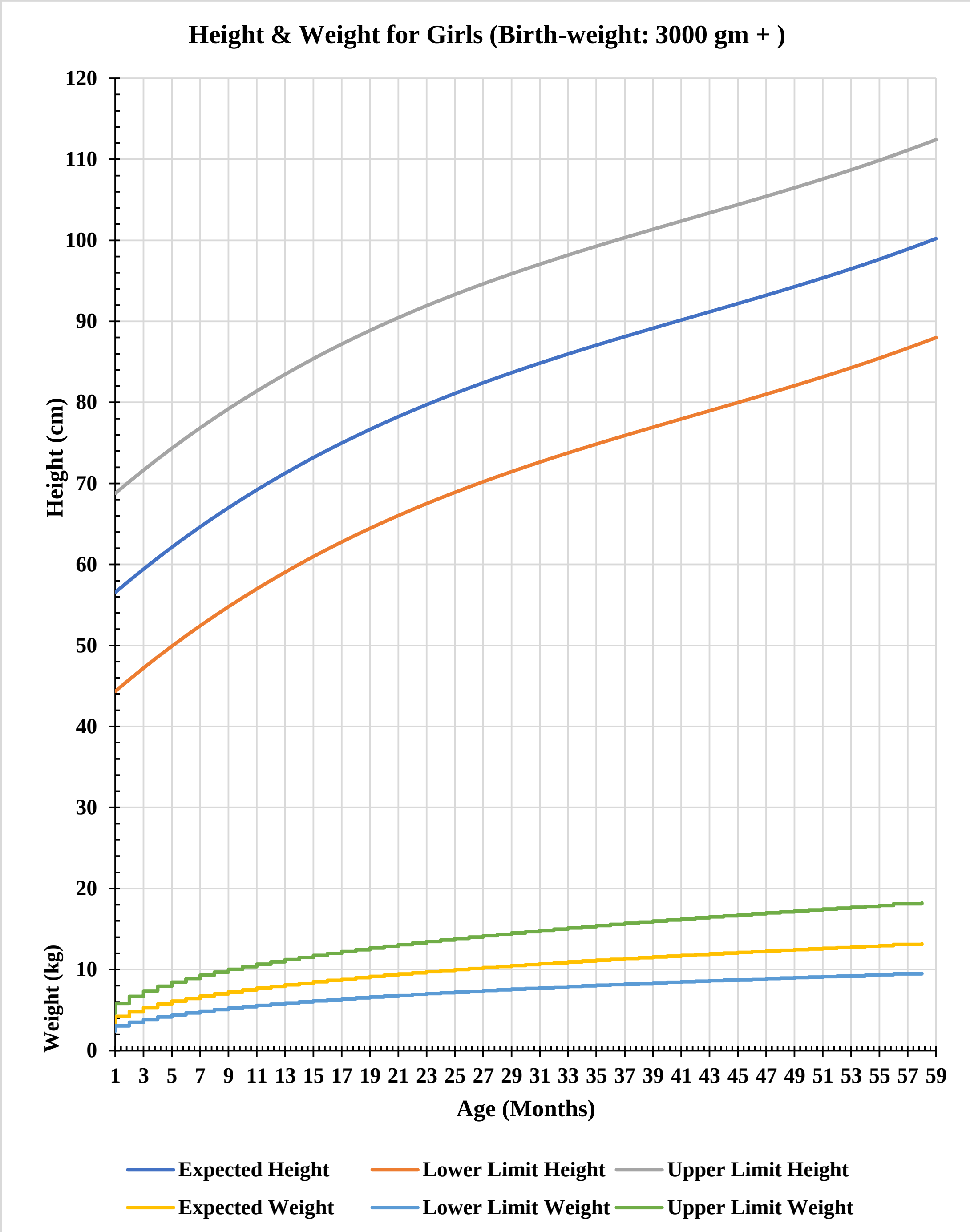


Figure 4.1.6(*b*): NFHS-4 (Birth-weight 2000 – 2499 gm): Estimated height and weight curves for girls of Central Region (India), Using Cubic and Power Models, respectively.



$Figure$ 4.1.6(c): NFHS-4 (Birth-weight 2500 – 2999 gm): Estimated height and weight curves for girls of Central Region (India), using Cubic and Power Models, respectively



$Figure$ 4.1.6(d): NFHS-4 (Birth-weight 3000+ gm): Estimated height and weight curves for girls of Central Region (India), using Cubic and Power Models, respectively

4.2 Eastern Region

This Region consists of 4 States, namely – Bihar, Jharkhand, Odisha, and Rajasthan.

4.2.1 Status of Under-Nutrition

Table 4.2.1: Prevalence rates (%) of stunting, wasting, and underweight

Eastern Region	Stunting	Wasting	Underweight
	38.2	**20.6**	**37.4**
Bihar	48.3	20.8	43.9
Jharkhand	45.3	29.0	47.8
Odisha	34.1	20.4	34.4
West Bengal	32.5	20.3	31.5

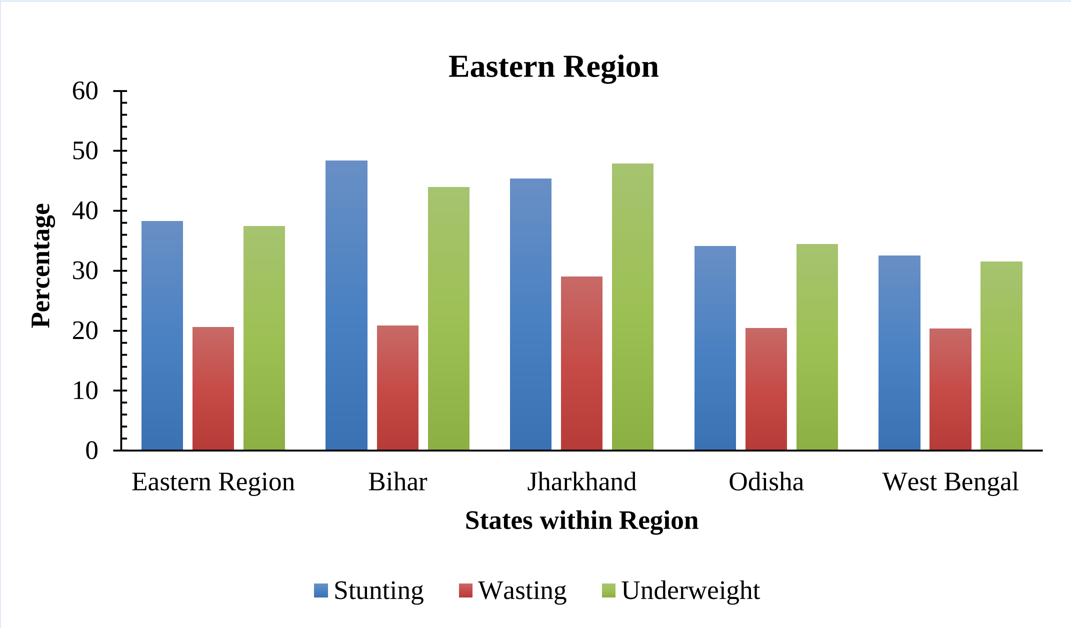


Figure 4.2.1: Prevalence rates (%) of stunting, wasting, and underweight

Table 4.2.1 and Figure 4.2.1 give over-all prevalence rates of stunting (38.2%), wasting (20.6%) and underweight (37.4%) in the Eastern Region. In this Region, stunting ranged between 32.5% (West Bengal) and 48.3 % (Bihar). The wasting was highest in Jharkhand (29.0%) and lowest in West Bengal (20.3%). Similarly, underweight was highest in Jharkhand (47.8%) and lowest in West Bengal (31.5%).

4.2.2 Stunting

Table 4.2.2: - Odds Ratio of stunting in under-5 children by socio-demographic variables

Socio-demographic variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.88	2.70	3.07
24 - 35	0.000	2.84	2.67	3.03
36 - 47	0.000	2.92	2.74	3.11
48 - 59	0.000	2.50	2.34	2.66
Child Sex				
Female *(Ref)*		1.00		
Male	0.054	1.04	1.00	1.08
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.77	2.39	3.20
Poorer	0.000	2.25	1.95	2.60
Middle	0.000	1.70	1.47	1.96
Richer	0.001	1.29	1.11	1.49
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.84	1.64	2.07
Primary	0.000	1.50	1.33	1.70
Secondary	0.001	1.22	1.09	1.36
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.579	0.98	0.92	1.05
Birth Order				
1 *(Ref)*		1.00		
2	0.013	1.06	1.01	1.12
3	0.000	1.16	1.09	1.22
4 & above	0.000	1.23	1.16	1.31
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.22	1.17	1.27
Overweight	0.000	0.70	0.64	0.76
Obese	0.000	0.59	0.49	0.71

Table 4.2.2 shows the odds ratio of stunting in children under the age of five by socio-demographic variables in the Eastern Region. When compared to children under the age of 12 months, odds of children being stunted were 2.8 times higher in the age groups of 12 to 23 months (OR: 2.88; 95% CI: 2.70 – 3.07, $p < 0.001$) and 24 to 35 months (OR: 2.84; 95% CI: 2.67 – 3.03, $p < 0.001$). In the age group of 36 to 47 months (OR: 2.92; 95% CI: 2.74 – 3.11, $p < 0.001$) compared to the age group of children under 12 months, odds of children being stunted was 2.9 times higher and similarly, when comparing to children under the age of 12 months, odds of children being stunted were 2.5 times higher in the age group of 48 to 59 months (OR: 2.50; 95% CI: 2.34 – 2.66, $p < 0.001$). Male children (OR: 1.04; 95% CI: 1.00 – 1.08, $p = 0.054$) experienced significantly higher odds of being stunted as compared to female children. There is no significant difference in the likelihood of stunting of children in males as compared to females.

The odds of having stunted children were 2.7 times higher in the poorest group (OR: 2.77; 95% CI: 2.39 – 3.20, $p < 0.001$) when compared to the richest group. The odds of having stunted children were 2.2 times higher in the poorer group (OR: 2.25; 95% CI: 1.95 – 2.60, $p < 0.001$) when compared to the richest group. The odds of stunting children were 1.7 times higher in the middle class (OR: 1.70; 95% CI: 1.47 – 1.96, $p < 0.001$) compared to the richest group, and similarly, the odds of stunting children were significantly higher in the richer group (OR: 1.29; 95% CI: 1.11 – 1.49, $p < 0.001$) when compared to the richest group.

The odds of having children who are stunted were 1.8 times higher for mothers with no education (OR: 1.84; 95% CI: 1.64 – 2.07, $p < 0.001$) than for mothers with higher levels of education. Mothers with only primary education (OR: 1.50; 95% CI: 1.33 – 1.70, $p < 0.001$) had 1.5 times higher odds of having stunted children than women with higher levels of education. In comparison to mothers with higher levels of education, mothers with only a secondary education (OR: 1.22; 95% CI: 1.09 – 1.36, $p < 0.001$) had 1.2 times higher odds of having children who would be stunted. Rural areas (OR: 0.98; 95% CI: 0.92 – 1.05, $p = 0.579$) experienced 2% lesser odds of having stunted children compared to urban children. There is no significant difference in the likelihood of stunting of children in rural areas as compared to urban areas.

Second birth order (OR: 1.06; 95% CI: 1.01 – 1.12, $p = 0.013$) had significantly higher odds of stunted children as compared to the first birth order. The odds of having stunted children were also significantly higher for the third birth order (OR: 1.16; 95% CI: 1.09 – 1.22, $p < 0.001$) compared to the first birth order. The odds of stunting in children were 1.2 times higher for birth order 4 and above (OR: 1.23; 95% CI: 1.16 – 1.31, $p < 0.001$) as compared to the first birth order. Women with an underweight BMI (< 18.5) (OR: 1.22; 95% CI: 1.17 – 1.27, $p < 0.001$) had 1.2 times greater odds of having children who are stunted than those with a normal BMI (18.5 - 24.9). Overweight mothers (OR: 0.70; 95% CI: 0.64 – 0.76, $p < 0.001$) had 30% lower odds of having children who were stunted than normal mothers. In comparison to normal mothers, obese mothers (OR: 0.59; 95% CI: 0.49 – 0.71, $p < 0.001$) had 41% lesser odds of stunting in children.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model are shown in Table 4.2.3 at 63.2% and 63.2%, respectively. However, sensitivity and specificity can be altered based on the requirements of the study and the requirement for diagnostic research. Area under the ROC curve is 0.674 (95% CI = 0.669 – 0.679) (Figure 4.2.2).

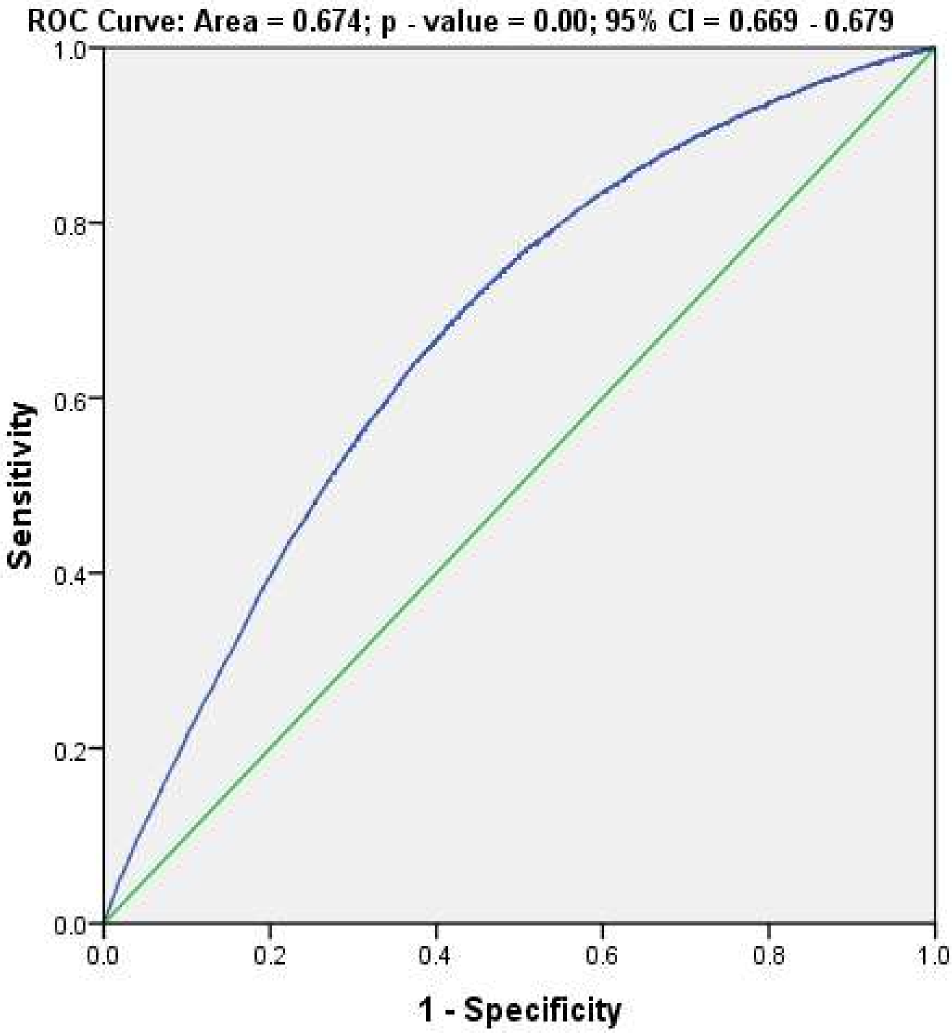


Figure 4.2.2: - Receiving Operating Characteristic (ROC) Curve highlighting the results for stunting of under-5 Children

Table 4.2.3: - Sensitivity & Specificity of the model at different cut off point

Probability (≥)	Sensitivity	Specificity
0.200161	0.970	0.109
0.203138	0.968	0.113
0.224281	0.959	0.142
0.235247	0.948	0.169
0.272358	0.919	0.241
0.282553	0.909	0.263
0.293938	0.899	0.286
0.304129	0.889	0.305
0.312181	0.879	0.327
0.320513	0.869	0.342
0.329685	0.859	0.362
0.339579	0.849	0.375
0.360894	0.808	0.438
0.364154	0.798	0.453
0.395355	0.758	0.505
0.401764	0.747	0.517
0.408130	0.739	0.525
0.412957	0.728	0.539
0.418785	0.718	0.549
0.422741	0.709	0.558
0.426568	0.701	0.567
0.428035	0.698	0.569
0.435217	0.686	0.581
0.440149	0.679	0.589
0.449313	0.668	0.599
0.456886	0.658	0.607
0.460062	0.648	0.618
0.466462	**0.632**	**0.632**
0.467531	0.629	0.635
0.473921	0.608	0.651
0.477279	0.597	0.660
0.510759	0.531	0.711
0.514222	0.523	0.717
0.563893	0.372	0.815
0.580590	0.286	0.861
0.611211	0.167	0.924
0.614732	0.153	0.931

4.2.3 Wasting

Table 4.2.4: - Odds Ratio of wasting in under-5 Children by socio demographic variables

Socio-demographic variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	0.74	0.69	0.79
24 - 35	0.000	0.64	0.60	0.68
36 - 47	0.000	0.55	0.52	0.59
48 - 59	0.000	0.58	0.54	0.62
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.08	1.03	1.13
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.002	1.27	1.09	1.48
Poorer	0.189	1.11	0.95	1.28
Middle	0.764	0.98	0.84	1.14
Richer	0.829	1.02	0.87	1.18
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.203	1.09	0.96	1.23
Primary	0.723	1.02	0.90	1.17
Secondary	0.567	1.04	0.92	1.16
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	0.87	0.81	0.94
Birth order				
1 *(Ref)*		1.00		
2	0.424	1.02	0.97	1.08
3	0.003	1.10	1.03	1.18
4 & above	0.008	1.09	1.02	1.17
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.43	1.36	1.49
Overweight	0.000	0.66	0.59	0.73
Obese	0.000	0.52	0.41	0.66

Table 4.2.4 represents odds ratio of wasting in under-5 children by socio demographic variables in the Eastern Region of India. In comparison to children under the age of 12 months, the odds of wasted children were 26% lower in the age group of 12 to 23 months (OR: 0.74; 95% CI: 0.69 - 0.79; p < 0.001). In comparison to children under the age of 12 months, the odds of wasted children were 36% lower in the age group of 24 to 35 months (OR: 0.64; 95% CI: 0.60 - 0.68; p < 0.001). As compared to children under the age of 12 months, the odds of wasted children were 45% lower in the age group of 36 to 47 months (OR: 0.55; 95% CI: 0.52 - 0.59; p < 0.001). When compared to children under the age of 12 months, the odds of wasted children were 42% lower in the age group 48 to 59 months (OR: 0.58; 95% CI: 0.54 – 0.62; p < 0.001). Male children (OR: 1.08; 95% CI: 1.03 – 1.13; p < 0.001) had notably higher odds of experiencing wasting in comparison to female children.

The odds of wasting in children were significantly higher in the poorest group (OR: 1.27; 95% CI: 1.09 – 1.48; p = 0.002) than in the richest group. The odds of having wasted children were also significantly higher in the poorer group (OR: 1.11; 95% CI: 0.95 – 1.28; p = 0.189) compared to the richest group. The odds of having wasted children was 2% lower in the middle group (OR: 0.98; 95% CI: 0.84 – 1.14; p = 0.764) as compared to the richest group. The odds of having wasted children were significantly higher for the richer group (OR: 1.02; 95% CI: 0.87 – 1.18; p = 0.829) compared to the richest group. When compared to the richest group, there is no substantial difference between the chance of wasted children in the poorer, middle, and richer groups.

When compared to mothers with higher levels of education, the odds of having wasted children were significantly higher for mothers with no formal education (OR: 1.09; 95% CI: 0.96 – 1.23; p = 0.203). In comparison to mothers with higher education levels, the odds of having wasted children were also significantly higher for women with primary (OR: 1.02; 95% CI: 0.90 – 1.17; p = 0.723) as well as secondary education (OR: 1.04; 95% CI: 0.92 – 1.16; p = 0.567). There is no substantial different between the odds of wasting in children among mothers with no education, primary education, and secondary education compared to women with higher levels of education. In comparison to urban areas, rural areas had 13% lower odds of wasting in children. (OR: 0.87; 95% CI: 0.81 – 0.94; p < 0.001).

For second birth order (OR: 1.02; 95% CI: 0.97 – 1.08; p = 0.424) compared to first birth order, the odds of having wasted children were significantly higher. When compared to first birth order, there is no clear differentiation in the likelihood of having wasted children in the second birth order. In the third birth order (OR: 1.10; 95% CI: 1.03 – 1.18; p < 0.001) as well as birth order 4 and above (OR: 1.09; 95% CI: 1.02 – 1.17; p < 0.001) compared to the first birth order, the odds of having wasted children were also significantly higher.

In comparison to normal mothers, underweight mothers (OR: 1.43; 95% CI: 1.36 – 1.49; p < 0.001) had 1.4 times higher odds of producing wasted children. As compared to normal mothers, overweight mothers (OR: 0.66; 95% CI: 0.59 – 0.73; p < 0.001) had 34% lower odds of having wasted children. In comparison to normal mothers, obese mothers (OR: 0.52; 95% CI: 0.41 – 0.66; p < 0.001) had 48% lower odds of giving birth to wasted children.

Diagnostic Evaluation of Logistic Regression

According to Table 4.2.5, the model's sensitivity and specificity are respectively 57.1 % and 57.4%. However, sensitivity and specificity may alter depending on the needs of the study and the necessity for the diagnostic study. Area under the ROC curve is 0.599 (95% CI: - 0.593 – 0.605) (Figure 4.2.3).

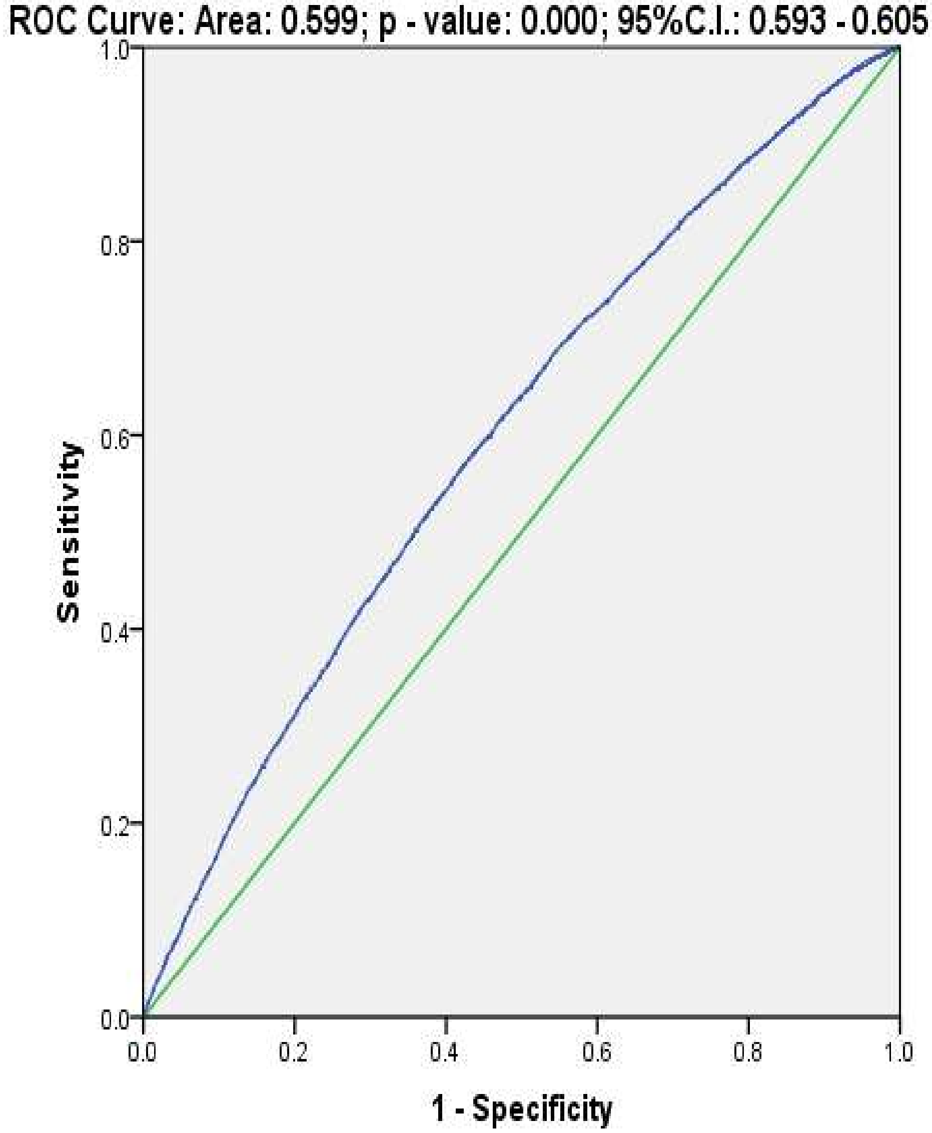


Figure 4.2.3: - Receiving Operation Characteristic (ROC) Curve highlighting the results for Wasting

Table 4.2.5: - Sensitivity & Specificity of the Model at different cut off points

Probability (≥)	**Sensitivity**	**Specificity**
0.144995	0.970	0.071
0.146125	0.969	0.073
0.153663	0.959	0.089
0.159965	0.949	0.107
0.162874	0.939	0.118
0.166539	0.929	0.135
0.169767	0.919	0.151
0.172671	0.909	0.163
0.174581	0.899	0.177
0.175100	0.898	0.178
0.178224	0.889	0.192
0.180525	0.878	0.211
0.182355	0.869	0.222
0.184571	0.859	0.234
0.186825	0.849	0.248
0.188512	0.839	0.263
0.190921	0.829	0.276
0.201418	0.769	0.349
0.201999	0.759	0.362
0.203088	0.747	0.377
0.204598	0.739	0.386
0.206421	0.729	0.399
0.216148	0.669	0.471
0.217688	0.659	0.480
0.220007	0.649	0.490
0.221716	0.639	0.502
0.222711	0.629	0.513
0.234400	0.577	0.568
0.235089	0.576	0.569
0.235278	0.575	0.570
0.235791	**0.571**	**0.573**
0.236173	0.570	0.574
0.241555	0.534	0.610
0.242352	0.530	0.613
0.262986	0.420	0.712
0.263553	0.418	0.715
0.284185	0.297	0.810
0.284331	0.296	0.812
0.322902	0.139	0.921
0.326356	0.132	0.925

4.2.4 Underweight

Tables 4.2.6: - Odds Ratio of underweight in under-5 children by socio-demographic variables

Socio-demographic variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1		
12 - 23	0.000	1.54	1.45	1.64
24 - 35	0.000	1.69	1.59	1.80
36 - 47	0.000	1.71	1.61	1.81
48 - 59	0.000	1.77	1.67	1.89
Child Sex				
Female *(Ref)*		1		
Male	0.366	0.98	0.95	1.02
Wealth Index				
Richest *(Ref)*		1		
Poorest	0.000	2.40	2.08	2.76
Poorer	0.000	2.00	1.73	2.30
Middle	0.000	1.46	1.27	1.68
Richer	0.006	1.22	1.06	1.41
Highest Education Level				
Higher *(Ref)*		1		
No Education	0.000	1.69	1.51	1.90
Primary	0.000	1.44	1.27	1.62
Secondary	0.000	1.26	1.13	1.40
Type of Residence				
Urban *(Ref)*		1		
Rural	0.000	0.89	0.84	0.95
Birth order				
1 *(Ref)*		1		
2	0.138	1.04	0.99	1.09
3	0.000	1.14	1.08	1.21
4 & above	0.000	1.25	1.18	1.32
BMI				
Normal *(Ref)*		1		
Underweight	0.000	1.60	1.53	1.66
Overweight	0.000	0.58	0.53	0.63
Obese	0.000	0.50	0.41	0.60

Table 4.2.6 shows odds ratio shows odds ratio of underweight in children under the age of five by socio-demographic variables in the Eastern Region of India. The odds of underweight children were 1.5 times higher in the age - group 12 - 23 months (OR: 1.54; 95% CI: 1.45 – 1.64; $p < 0.001$) as compared to the age - group less than 12 months. In comparison to the age group less than 12 months, the odds of having an underweight child were 1.6 times higher in the 24-to-35-month age group (OR: 1.69; 95% CI: 1.59 – 1.80; $p < 0.001$). The odds of having an underweight child were 1.7 times higher in the 36-to-47-month (OR: 1.71; 95% CI: 1.61 – 1.81; $p < 0.001$) and4.2.748-to-59-month (OR: 1.77; 95% CI: 1.67 – 1.89; $p < 0.001$) age groups compared to the age group less than 12 months. The odd of having an underweight child was 2% lower in males (OR: 0.98; 95% CI: 0.95 – 1.02; $p = 0.366$) than in females. There is no clear significant difference in the likelihood of underweight children in males as compared to female children.

The odd of having an underweight child was 2.4 times higher in the poorest group (OR: 2.40; 95% CI: 2.08 – 2.76; $p < 0.001$) compared to the richest group. The odd of having an underweight child was two times higher in the poorer group (OR: 2.40; 95% CI: 2.08 – 2.76; $p < 0.001$) than in the richest group. The odds of having an underweight child was 1.4 times higher in the middle class (OR: 1.46; 95% CI: 1.27 – 1.68; $p < 0.001$) than in the richest group. The odd of having an underweight child was 1.2 times higher in the richer group (OR: 1.22; 95% CI: 1.06 – 1.41; $p < 0.006$) compared to the richest group.

The odds of having underweight children were 1.6 times higher for mothers with no education (OR: 1.69; 95% CI: 1.51 – 1.90; $p < 0.001$) than for mothers with higher levels of education. Mothers with primary education (OR: 1.44; 95% CI: 1.27 – 1.62; $p < 0.001$) had 1.4 times higher odds of having underweight children than mothers with higher levels of education. A mother with only a secondary education (OR: 1.26; 95% CI: 1.13 – 1.40; p < 0.001) had 1.2 times greater odds of giving birth to underweight children than a mother with a higher education. In rural areas (OR: 0.89; 95% CI: 0.84 – 0.95; p < 0.001), the odds of having underweight children were 11% lower than in urban areas.

In comparison to the first birth order, the odds of having underweight children were significantly greater in the second birth order (OR: 1.04; 95% CI: 0.99 – 1.09; p = 0.138). There is no significant difference in the likelihood of underweight children in second birth order compared to first birth order. The odds of producing underweight children were 1.1 times higher in the third birth order (OR: 1.14; 95% CI: 1.08 – 1.21; p < 0.001) than it was in the first birth order. In the birth order of 4 and above (OR: 1.25; 95% CI: 1.18 – 1.32; p < 0.001) compared to the first birth order, the odds of having underweight children were 1.2 times higher.

Underweight mothers (OR: 1.60; 95% CI: 1.53 – 1.66; p < 0.001) compared to normal mothers had 1.6 times higher odds of having underweight children. Overweight mothers (OR: 0.58; 95% CI: 0.53 – 0.63; p < 0.001) had 42% lower odds of having underweight children as compared to normal mothers. Obese mothers (OR: 0.50; 95% CI: 0.41 – 0.60; p < 0.001) had 50% lesser odds of giving birth to underweight children than those with normal mothers.

Diagnostic Evaluation of Logistic Regression

According to Table 4.2.7, the model's sensitivity and specificity are both 61.1%. Sensitivity and specificity, however, might change depending on the needs of the study and the necessity for diagnostic research. Area under the ROC curve is 0.652 (95% CI: - 0.647 – 0.647) (Figure 4.2.4).

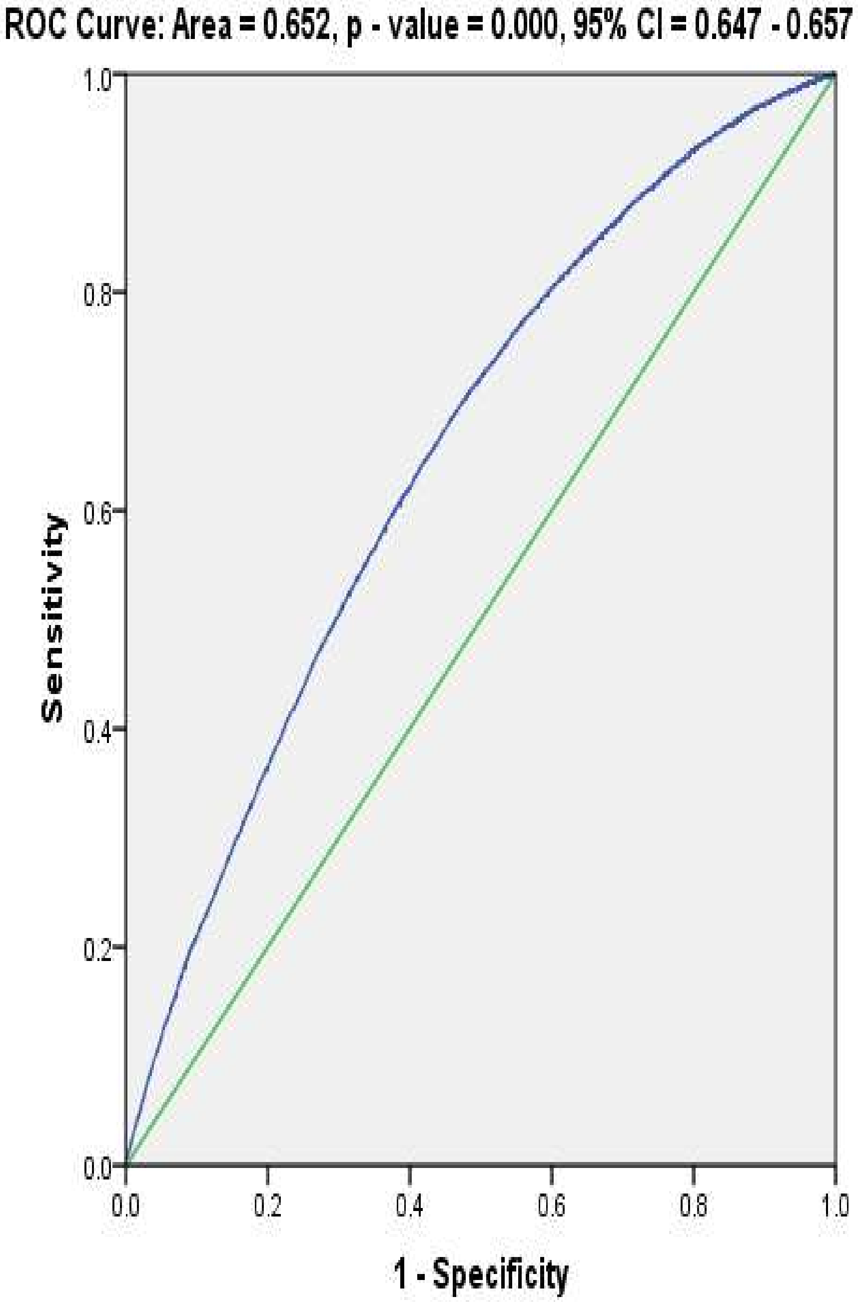


Figure 4.2.4: - Receiving Operating Characteristic (ROC) Curve highlighting the results for underweight

Table 4.2.7: - Sensitivity & Specificity of the Model at different cut off points

Probability (≥)	Sensitivity	Specificity
0.2153203	0.970	0.108
0.2187521	0.969	0.111
0.2382738	0.959	0.134
0.2583684	0.949	0.158
0.2762214	0.929	0.202
0.2869010	0.919	0.218
0.2946633	0.909	0.238
0.3007727	0.898	0.256
0.3113485	0.879	0.288
0.3165800	0.869	0.302
0.3254074	0.859	0.319
0.3327466	0.849	0.333
0.3402988	0.839	0.349
0.3513791	0.828	0.365
0.3514850	0.827	0.366
0.3577745	0.819	0.377
0.3635848	0.809	0.392
0.3696727	0.799	0.405
0.3737510	0.788	0.419
0.3774438	0.778	0.435
0.3819109	0.769	0.445
0.3861411	0.759	0.457
0.3910713	0.749	0.468
0.4031150	0.719	0.502
0.4076128	0.709	0.515
0.4120101	0.699	0.525
0.4151052	0.689	0.535
0.4188360	0.678	0.546
0.4230926	0.659	0.565
0.4268366	0.649	0.575
0.4309123	0.639	0.585
0.4353422	0.629	0.594
0.4397111	0.619	0.602
0.4450066	**0.611**	**0.611**
0.4455531	0.610	0.612
0.4878781	0.498	0.706
0.4898122	0.489	0.713
0.5263368	0.331	0.823
0.5289643	0.325	0.827
0.5749560	0.193	0.911
0.5802705	0.181	0.918

4.2.5 Estimation of Child Height

Table 4.2.8 represents the test between subjects' effects, reveals child age, educational level, wealth index, sex of child and BMI is having a significant effect on Child Height except type of residence, birth order and respondent occupation.

Table 4.2.8: Tests of between-subjects effects

Dependent Variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	717.881	1	717.881	17.7	< 0.001
	Error	4179.154	103.04	40.559a		
Child Age	Hypothesis	1206.691	4	301.673	8.2	< 0.001
	Error	297365.581	8119	36.626b		
Birth Order	Hypothesis	80.23	3	26.743	0.7	0.534
	Error	297365.581	8119	36.626b		
Education level	Hypothesis	1062.096	3	354.032	9.6	< 0.001
	Error	297365.581	8119	36.626b		
Respondent Occupation	Hypothesis	90.514	2	45.257	1.2	0.291
	Error	297365.581	8119	36.626b		
Type of Residence	Hypothesis	16.739	1	16.739	0.4	0.499
	Error	297365.581	8119	36.626b		
Wealth Index	Hypothesis	4030.701	4	1007.675	27.5	< 0.001
	Error	297365.581	8119	36.626b		
BMI	Hypothesis	1094.796	3	364.932	9.9	< 0.001
	Error	297365.581	8119	36.626b		
Child Sex	Hypothesis	3455.73	1	3455.73	94.3	< 0.001
	Error	297365.581	8119	36.626b		
FIT*	Hypothesis	82547.498	1	82547.498	2253.8	< 0.001
	Error	297365.581	8119	36.626b		
Birth Weight	Hypothesis	941.591	1	941.591	25.7	< 0.001
	Error	297365.581	8119	36.626b		
a .001 MS (Child Sex) + .999 MS (Error)						
b MS(Error)						

**Note: - ***Fit for Child Height with Child Age from CURVEFIT using Cubic Model:

$$Child\ Height = 53.972 + 1.706Age - 0.030Age^2 + 0.00024Age^3$$

Table 4.2.9 represents factors associated with child height in eastern region. Children born in the first birth order (OR: 0.96, 95% CI: 0.64 – 1.44, p = 0.836) have a height which is 4% less than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.12, 95% CI: 0.75 – 1.69, p = 0.58) have a higher height than children born in the 4 & above birth order. Children born in the third birth order (OR: 0.84, 95% CI: 0.54 – 1.30, p = 0.431) have a height which is 16% less than children born in the 4 & above birth order.

Children's height is 81% less in mothers with no education (OR: 0.19, 95% CI: 0.09 – 0.38, p < 0.05) compared to mothers with higher education. Children's height is 76% less in mothers with primary education (OR: 0.24, 95% CI: 0.11 – 0.51, p < 0.05) compared to mothers with higher education. Children's height is 59% less in mothers with secondary education (OR: 0.41, 95% CI: 0.21 – 0.80, p < 0.05) compared to mothers with higher education.

Children's height is higher in mothers with no occupation (OR: 1.18, 95% CI: 0.75 – 1.86, p = 0.467) compared to agricultural mothers. As compared to agricultural mothers, the height of children is 15% less in mothers with other occupations (OR: 0.85, 95% CI: 0.47 – 1.54, p = 0.581). As compared to rural region, the height of children is higher in urban region (OR: 1.15, 95% CI: 0.76 – 1.74, p = 0.499).

Children in the poorest group (OR: 0.02, 95% CI: 0.01 – 0.05, p < 0.05) have 98% less height than children in the richest group. Children in the poorer group (OR: 0.04, 95% CI: 0.02 – 0.09, p < 0.05) have 96% less height than children in the richest group. Children in the middle group (OR: 0.10, 95% CI: 0.04 – 0.23, p < 0.05) have 90% less height than children in the richest group. Children in the richer group (OR: 0.20, 95% CI: 0.09 – 0.46, p < 0.05) have 80% less height than children in the richest group.

The height of children with normal mother (OR: 0.12, 95% CI: 0.04 – 0.38, $p < 0.05$) is 88% less than that of those with obese mother. The height of children with underweight mother (OR: 0.09, 95% CI: 0.03 – 0.28, $p < 0.05$) is 91% lesser than that of children with obese mother. The height of children with overweight mother (OR: 0.30, 95% CI: 0.09 – 10.00, $p < 0.05$) is 70% lesser than that of children with obese mother. As compared to female children, height of male children (OR: 3.69, 95% CI: 2.84 – 4.81, $p < 0.05$) is 3.6 times higher.

Table 4.2.9: Factors associated with Child Height in Eastern Region

Dependent variable: Child Height					
Parameter	B	p - value	95% CI		OR (95% CI)
			LL	UL	
Birth Order					
1	-0.043	0.836	-0.454	0.367	0.96 (0.64, 1.44)
2	0.115	0.58	-0.293	0.523	1.12 (0.75, 1.69)
3	-0.177	0.431	-0.618	0.263	0.84 (0.54, 1.30)
4 & above	0				
Education Level					
No Education	-1.678	0.000	-2.398	-0.957	0.19 (0.09, 0.38)
Primary	-1.441	0.000	-2.206	-0.675	0.24 (0.11, 0.51)
Secondary	-0.885	0.009	-1.544	-0.225	0.41 (0.21, 0.80)
Higher	0				
Respondent Occupation					
No Occupation	0.168	0.467	-0.284	0.620	1.18 (0.75, 1.86)
Other	-0.168	0.581	-0.765	0.429	0.85 (0.47, 1.54)
Agriculture	0				
Type of Residence					
Urban	0.143	0.499	-0.271	0.556	1.15 (0.76, 1.74)
Rural	0				
Wealth Index					
Poorest	-3.891	0.000	-4.747	-3.034	0.02 (0.01, 0.05)
Poorer	-3.261	0.000	-4.098	-2.424	0.04 (0.02, 0.09)
Middle	-2.318	0.000	-3.148	-1.488	0.10 (0.04, 0.23)
Richer	-1.617	0.000	-2.449	-0.785	0.20 (0.09, 0.46)
Richest	0				
BMI					
Normal	-2.083	0.000	-3.196	-0.971	0.12 (0.04, 0.38)
Underweight	-2.407	0.000	-3.539	-1.276	0.09 (0.03, 0.28)
Overweight	-1.199	0.049	-2.392	-0.005	0.30 (0.09, 10.00)
Obese	0				
Child Sex					
Male	1.306	0.000	1.043	1.57	3.69 (2.84, 4.81)
Female	0				
FIT*	1.104	0.000	1.058	1.149	3.02 (2.88, 3.16)
Birth Weight	1.068	0.000	0.655	1.481	2.91 (1.93, 4.40)

**Note: - ***Fit for Child Height with Child Age from CURVEFIT using Cubic Model:

$$Child\ Height = 53.972 + 1.706Age - 0.030Age^2 + 0.00024Age^3$$

Table 4.2.10 represents the descriptive statistics of child height by birth order. The mean height of a child in first and second birth order is around 84.4 cm and 84.5 cm, respectively. The mean height of a child in third and 4 & above birth order is around 84.3 cm and 84.5 cm, respectively.

Table 4.2.10: Descriptive statistics of Child Height by birth order

Dependent variable: Child Height				
Birth Order	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	84.41	0.22	83.98	84.84
2	84.57	0.22	84.14	85.00
3	84.28	0.24	83.80	84.75
4 & above	84.45	0.25	83.97	84.93

Table 4.2.11 represents a pairwise comparison of child height by birth order. Mean difference of child weight between first and second birth order (M D = -0.158, 95% CI: -0.493 to 0.176, p-value = 0.353), between first and third birth order (M D = 0.134, 95% CI: -0.265 to 0.533, p-value = 0.511) and first and 4 & above birth order (M D = -0.043, 95% CI: -0.454 to 0.367, p-value = 0.836) is statistically insignificant. Mean difference of child height between second and third birth order (M D = 0.292, 95% CI: -0.108 to 0.693, p-value = 0.153) and second and 4 & above birth order (M D = 0.115, 95% CI: -0.293 to 0.523, p-value = 0.580) is statistically insignificant. Mean difference of child height between third and 4 & above birth order (M D = -0.177, 95% CI: -0.618 to 0.263, p-value = 0.431).

Table 4.2.11: - Pairwise comparisons of Child Height by birth order

Dependent variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% C.I. for Difference	
					LL	UL
1	2	-0.158	0.171	0.353	-0.493	0.176
	3	0.134	0.203	0.511	-0.265	0.533
	4 & above	-0.043	0.21	0.836	-0.454	0.367
2	3	0.292	0.204	0.153	-0.108	0.693
	4 & above	0.115	0.208	0.580	-0.293	0.523
3	4 & above	-0.177	0.225	0.431	-0.618	0.263

Table 4.2.12 represents the descriptive statistics of child height by educational level. The mean Height of a child for mothers with no education is around 83.7 cm. For mothers with primary education, average height of the child is around 83.9 cm. For mothers with secondary education, average height of the child is around 84.5 cm. Similarly, for mothers with higher education, the average child's height is around 85.4 cm.

Table 4.2.12: - Descriptive statistics of Child Height by educational level

Dependent variable: Child Height				
Educational Level	Mean	Std. Error	95% C.I.	
			LL	UL
No education	83.75	0.22	83.31	84.19
Primary	83.99	0.27	83.46	84.51
Secondary	84.54	0.21	84.13	84.95
Higher	85.43	0.35	84.75	86.11

Table 4.2.13 represents a pairwise comparison of child height by educational level. Mean difference of child height between mothers with no education and secondary education (M D = -0.793, 95% CI: -1.15 to -0.44, p-value < 0.05), mothers with no education and higher education level (M D = -1.678, 95% CI: -2.40 to -0.96, $p < 0.05$) is statistically significant. Mean difference of child height between mothers with primary and secondary education (M D = -0.556, 95% CI: -1.00 to -0.11, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers

with primary and higher education (M D = -1.441, 95% CI: -2.21 to -0.68, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.885, 95% CI: -1.54 to -0.23, p-value < 0.05) is statistically significant.

Table 4.2.13: - Pairwise comparisons of Child Height by educational level

Dependent Variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% C.I.	
					LL	UL
No education	Primary	-0.237	0.22	0.281	-0.67	0.19
	Secondary	-0.793*	0.18	0.000	-1.15	-0.44
	Higher	-1.678*	0.37	0.000	-2.40	-0.96
Primary	Secondary	-0.556*	0.23	0.015	-1.00	-0.11
	Higher	-1.441*	0.39	0.000	-2.21	-0.68
Secondary	Higher	-0.885*	0.34	0.009	-1.54	-0.23
*Mean difference is significant at the 0.05 level						

Table 4.2.14 represents the descriptive statistics of child height by respondent occupation. Mean height of the child for mothers with no occupation is around 84.6 cm. But, for mothers with other occupation and agricultural mothers, average height of the child is around 84.2 cm and 84.4 cm, respectively.

Table 4.2.14: - Descriptive statistics of Child Height by respondent occupation

Dependent variable: Child Height				
Respondent Occupation	Mean	Std. Error	95% C.I.	
			LL	UL
No Occupation	84.59	0.18	84.25	84.94
Others	84.26	0.27	83.74	84.78
Agriculture	84.43	0.28	83.88	84.97

Table 4.2.15 represents a pairwise comparison of child height by respondent occupation. Mean difference of child height between mothers with no occupation and mothers with other occupation (M D = 0.34, 95% CI: - 0.11 to 0.78, p = 0.141) is statistically insignificant. Similarly, mean difference of child height between mothers with no occupation and mothers doing agriculture (M D = 0.17, 95% CI: -0.28 to 0.62, p = 0.467) is statistically insignificant. Mean difference of child height between

mothers with other occupation and mothers doing agriculture (M D = -0.17, 95% CI: -0.77 to 0.48, p = 0.581) is statistically insignificant.

Table 4.2.15: - Pairwise comparisons of Child Height by respondent occupation

Dependent variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% C.I.	
					LL	UL
No Occupation	Others	0.34	0.23	0.141	-0.11	0.78
	Agriculture	0.17	0.23	0.467	-0.28	0.62
Others	Agriculture	-0.17	0.30	0.581	-0.77	0.43

Table 4.2.16 represents the descriptive statistics of Child Height by Type of Residence. Mean height of child urban as well as rural regions is around 84.5 cm and 84.3 cm, respectively.

Table 4.2.16: - Descriptive statistics of Child Height by type of residence

Dependent variable: Child Height				
Type of Residence	Mean	Std. Error	95% C.I.	
			LL	UL
Urban	84.50	0.24	84.03	84.96
Rural	84.35	0.20	83.95	84.75

Table 4.2.17 represents a pairwise comparison of child height by Type of Residence. Mean difference of child height between urban region and rural region (M D = 0.14, 95% CI: -0.27 to 0.56, p-value = 0.50), is statistically insignificant.

Table 4.2.17: - Pairwise comparisons of Child Height by type of residence

Dependent variable: Child Height						
Type Of Residence	Type Of Residence	Mean Difference	Std. Error	p - value	95% C.I.	
					LL	UL
Urban	Rural	0.14	0.21	0.50	-0.27	0.56

Table 4.2.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 82 cm. In the poorer and middle groups, children's average height is around 83 cm and 84 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 85 cm and 86 cm, respectively.

Table 4.2.18: - Descriptive statistics of Child Height by wealth index

Dependent variable: Child Height				
Wealth Index	Mean	Std. Error	95% C.I.	
			LL	UL
Poorest	82.75	0.24	82.27	83.23
Poorer	83.38	0.25	82.89	83.87
Middle	84.33	0.26	83.81	84.84
Richer	85.03	0.29	84.46	85.60
Richest	86.64	0.38	85.91	87.38

Table 4.2.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and poorer group (M D = - 0.630, 95% CI: - 0.974 to - 0.286, $p < 0.05$), between poorest group and middle group (M D = - 1.573, 95% CI: - 2.014 to -1.132, $p < 0.05$), between poorest group and richer group (M D = - 2.274, 95% CI: -2.868 to -1.68, $p < 0.05$), and between poorest group and richest group (M D = - 3.891, 95% CI: - 4.747 to – 3.034, $p < 0.05$) is statistically significant. Mean difference of child height between poorer group and middle group (M D = - 0.943, 95% CI: - 1.385 to – 0.502, $p < 0.05$), between poorer group and richer group (M D = - 1.644, 95% CI: - 2.222 to – 1.066, $p < 0.05$), and between poorer group and richest group (M D = - 3.261, 95% CI: - 4.098 to – 2.424, $p < 0.05$) is statistically significantly. Mean difference of child height between middle group and richer group (M D = - 0.701, 95% CI: - 1.294 to – 0.107, $p < 0.05$), between middle group and the richest group (M D = - 2.318, 95% CI: - 3.148 to – 1.488, $p < 0.05$) is statistically significant. Mean difference of child height between richer group and richest group (M D = - 1.617, 95% CI: - 2.449 to – 0.785, $p < 0.05$) is statistically significant.

Table 4.2.19: - Pairwise comparisons of Child Height by wealth index

Dependent variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Poorest	Poorer	-0.630*	0.175	0.000	-0.974	-0.286
	Middle	-1.573*	0.225	0.000	-2.014	-1.132
	Richer	-2.274*	0.303	0.000	-2.868	-1.680
	Richest	-3.891*	0.437	0.000	-4.747	-3.034
Poorer	Middle	-0.943*	0.225	0.000	-1.385	-0.502
	Richer	-1.644*	0.295	0.000	-2.222	-1.066
	Richest	-3.261*	0.427	0.000	-4.098	-2.424
Middle	Richer	-0.701*	0.303	0.021	-1.294	-0.107
	Richest	-2.318*	0.423	0.000	-3.148	-1.488
Richer	Richest	-1.617*	0.424	0.000	-2.449	-0.785
*Mean difference is significant at the .05 level						

Table 4.2.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 85 cm. Similarly, children's average height in females is around 83.7 cm.

Table 4.2.20: - Descriptive statistics of Child Height by child sex

Dependent variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	85.079	0.205	84.677	85.481
Female	83.773	0.208	83.365	84.180

Table 4.2.21 represents a pairwise comparison of child height by Child Sex. Mean difference of child height between in male children and female children (M D = 1.306, 95% CI: 1.043 to 1.570, p-value < 0.05) is statistically significant.

Table 4.2.21: - Pairwise comparisons of Child Height By child sex

Dependent variable: Child Height						
Child Sex	Child Sex	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Male	Female	1.306*	0.134	0.000	1.043	1.57
*Mean difference is significant at the 0.05 level						

Table 4.2.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as in underweight BMI is around 83 cm. The average height of a child with an overweight BMI is around 84.6 cm. Similarly, children's average height in obese BMI is around 85.8 cm.

Table 4.2.22: - Descriptive statistics of Child Height by BMI

Dependent variable: Child Height				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	83.77	0.16	83.46	84.07
Underweight	83.44	0.19	83.08	83.80
Overweight	84.65	0.28	84.10	85.20
Obese	85.85	0.56	84.74	86.95

Table 4.2.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.324, 95% CI: 0.030 to 0.622, $p < 0.05$), between normal BMI and overweight BMI (M D = - 0.885, 95% CI: - 1.43 to -0.341, $p < 0.05$) is statistically significant. But, mean difference of child height between normal BMI and obese BMI (M D = - 2.083, 95% CI: - 3.20 to - 0.97, $p < 0.05$) is statistically significant. Mean difference of child height between underweight BMI and overweight BMI (M D = - 1.209, 95% CI: - 1.79 to - 0.63, $p < 0.05$) and between underweight BMI and obese BMI (M D = - 2.407, 95% CI: - 3.54 to - 1.28, $p < 0.05$) is statistically significant. Mean difference of child height between overweight BMI and obese BMI (M D = - 1.199, 95% CI: - 2.39 to - 0.01, $p < 0.05$) is statistically significant.

Table 4.2.23: - Pairwise comparisons of Child Height by BMI

Dependent variable: Child Height						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Normal	Underweight	0.324*	0.15	0.030	0.03	0.62
	Overweight	-0.885*	0.28	0.001	-1.43	-0.34
	Obese	-2.083*	0.57	0.000	-3.20	-0.97
Underweight	Overweight	-1.209*	0.30	0.000	-1.79	-0.63
	Obese	-2.407*	0.58	0.000	-3.54	-1.28
Overweight	Obese	-1.199*	0.61	0.049	-2.39	-0.01
*Mean difference is significant at the 0.05 level						

4.2.6 Estimation of Child Weight

Table 4.2.24 represents the test between subjects' effects, reveals child age, birth order, educational level, wealth index, sex of child and BMI is having a significant effect on Child Weight except respondent occupation and place of residence.

Table 4.2.24: Tests of Between-Subjects Effects

Dependent Variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	5.094	1	5.094	1.168	0.315
	Error	31.062	7.122	4.361a		
Child Age	Hypothesis	284.398	4	71.099	25.978	< 0.001
	Error	22081.62	8068	2.737b		
Birth order	Hypothesis	39.691	3	13.23	4.834	0.002
	Error	22081.62	8068	2.737b		
Educational Level	Hypothesis	107.65	3	35.883	13.111	< 0.001
	Error	22081.62	8068	2.737b		
Respondent Occupation	Hypothesis	9.264	2	4.632	1.692	0.184
	Error	22081.62	8068	2.737b		
Place of Residence	Hypothesis	0.048	1	0.048	0.017	0.895
	Error	22081.62	8068	2.737b		
Wealth Index	Hypothesis	294.993	4	73.748	26.946	< 0.001
	Error	22081.62	8068	2.737b		
BMI	Hypothesis	504.255	3	168.085	61.414	< 0.001
	Error	22081.62	8068	2.737b		
Child Sex	Hypothesis	465.786	1	465.786	170.185	< 0.001
	Error	22081.62	8068	2.737b		
FIT*	Hypothesis	3807.021	1	3807.021	1390.978	< 0.001
	Error	22081.62	8068	2.737b		
Birth Weight	Hypothesis	106.556	1	106.556	38.932	< 0.001
	Error	22081.62	8068	2.737b		
a .004 MS (Child Sex) + .996 MS (Error)						
b MS(Error)						

Note: - *Fit for Child Weight with Child Age from CURVEFIT using Power Model: –

$$Child\ Weight = 3.203\ Child\ Age^{0.351}$$

Table 4.2.25 represents factors associated with child weight in eastern region. When compared to children between the ages of 48 and 59 months, children under the age of 12 months (OR: 1.17, 95% CI: 0.79 – 1.72, p = 0.442) weigh 1.2 times higher. The weight of children between the ages of 12 and 23 months (OR: 0.72, 95% CI: 0.56 – 0.93, p < 0.05) is 28 % lesser than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.69, 95% CI: 0.58 – 0.83, p < 0.05) weigh 31% lesser than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.82, 95% CI: 0.72 – 0.94, p < 0.05) weigh 20% less.

Children born in the first birth order (OR: 1.17, 95% CI: 1.04 – 1.31, p < 0.05) weigh 1.2 times higher than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.04, 95% CI: 0.93 – 1.17, p = 0.455) weigh more than children born in the 4 & above birth order. Children born in the third birth order (OR: 0.97, 95% CI: 0.86 – 1.09, p = 0.568) weigh 3% less than children born in the 4 & above birth order.

Children's weight is 42% less in mothers with no education (OR: 0.58, 95% CI: 0.47 – 0.70, p < 0.05) compared to mothers with higher education. Children's weight is 31% less in mothers with primary education (OR: 0.69, 95% CI: 0.56 – 0.85, p < 0.05) compared to mothers with higher education. Children's weight is 26% less in mothers with secondary education (OR: 0.74, 95% CI: 0.62 – 0.89, p < 0.05) compared to mothers with higher education.

Children's weight is more in mothers with no occupation (OR: 1.10, 95% CI: 0.97 – 1.24, p = 0.152) compared to mothers with higher education. As compared to women with higher education, the weight of children is higher among mothers with other occupations (OR: 1.01, 95% CI: 0.86 – 1.19, $p = 0.925$). As compared to rural region, the weight of children is high in urban region (OR: 1.01, 95% CI: 0.90 – 1.13, $p = 0.825$).

Children in the poorest group (OR: 0.39, 95% CI: 0.31 – 0.49, $p < 0.05$) have 61% less weight than children in the richest group. Children in the poorer group (OR: 0.48, 95% CI: 0.38 – 0.61, $p < 0.05$) have 52% less weight than children in the richest group. Children in the middle group (OR: 0.65, 95% CI: 0.52 – 0.81, $p < 0.05$) have 35% less weight than children in the richest group. Children in the richer group (OR: 0.71, 95% CI: 0.57 – 0.89, $p < 0.05$) have 29% less weight than children in the richest group.

The weight of children with normal women (OR: 0.36, 95% CI: 0.26 – 0.48, $p < 0.05$) is 64% lower than that of those with obese women. The weight of children with underweight women (OR: 0.27, 95% CI: 0.20 – 0.36, $p < 0.05$) is around 73% lesser than that of children with obese women. The weight of children with overweight women (OR: 0.68, 95% CI: 0.49 – 0.95, $p < 0.05$) is 32 % lesser than that of children with obese women. As compared to female children, weight of male children (OR: 1.62, 95% CI: 1.51 – 1.74, $p < 0.05$) is around 2 times higher.

Table 4.2.25: Factors Associated with Child Weight in Eastern Region

Dependent variable: Child Weight					
Parameter	B	p - value	95% CI		OR (95% CI)
			LL	UL	
Child Age (Months)					
< 12	0.153	0.442	-0.238	0.545	1.17 (0.79, 1.72)
12 - 23	-0.325	0.012	-0.58	-0.071	0.72 (0.56, 0.93)
24 - 35	-0.368	0.000	-0.544	-0.191	0.69 (0.58, 0.83)
36 - 47	-0.196	0.003	-0.326	-0.067	0.82 (0.72, 0.94)
48 – 59 *(Ref.)*	1				
Birth Order					
1	0.157	0.006	0.044	0.27	1.17 (1.04, 1.31)
2	0.043	0.455	-0.069	0.155	1.04 (0.93, 1.17)
3	-0.035	0.568	-0.156	0.086	0.97 (0.86, 1.09)
4 & above *(Ref.)*	1				
Education Level					
No Education	-0.548	0.000	-0.746	-0.351	0.58 (0.47, 0.70)
Primary	-0.375	0.000	-0.585	-0.165	0.69 (0.56, 0.85)
Secondary	-0.303	0.001	-0.484	-0.122	0.74 (0.62, 0.89)
Higher *(Ref.)*	1				
Respondent Occupation					
No Occupation	0.091	0.152	-0.033	0.214	1.10 (0.97, 1.24)
Others	0.008	0.925	-0.156	0.172	1.01 (0.86, 1.19)
Agriculture *(Ref.)*	1				
Type of Residence					
Urban	0.008	0.895	-0.106	0.121	1.01 (0.9, 1.13)
Rural *(Ref.)*	1				
Wealth Index					
Poorest	-0.943	0.000	-1.178	-0.708	0.39 (0.31, 0.49)
Poorer	-0.731	0.000	-0.96	-0.501	0.48 (0.38, 0.61)
Middle	-0.432	0.000	-0.66	-0.205	0.65 (0.52, 0.81)
Richer	-0.341	0.003	-0.569	-0.113	0.71 (0.57, 0.89)
Richest *(Ref.)*	1				
BMI					
Normal	-1.035	0.000	-1.34	-0.731	0.36 (0.26, 0.48)
Underweight	-1.319	0.000	-1.628	-1.009	0.27 (0.20, 0.36)
Overweight	-0.379	0.023	-0.705	-0.053	0.68 (0.49, 0.95)
Obese *(Ref.)*	1				
Child Sex					
Male	0.481	0.000	0.409	0.553	1.62 (1.51, 1.74)
Female *(Ref.)*	1				
FIT*	1.054	0.000	0.999	1.11	2.87 (2.72, 3.03)
Birth Weight	0.361	0.000	0.248	0.474	1.43 (1.28, 1.61)

Note: - *Fit for Child Weight with Child Age from CURVEFIT using Power Model: –

$$Child\ Weight = 3.203\ Child\ Age^{0.351}$$

Table 4.2.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in less than 12 months age group is around 11.2 kg. The mean weight of a child in 12 - 23 months and 24 - 35 months age group is around 10.6 kg. The mean weight of a child in 36 - 47 months age group is around 10.8 kg. The mean weight of a child in 48 - 59 months age group is around 11 kg.

Table 4.2.26: Descriptive statistics of Child Weight by child age

Dependent variable: Child Weight				
Child Age	Mean	Std. Error	95% CI	
			LL	UL
<12	11.153	0.126	10.906	11.401
12 - 23	10.675	0.074	10.53	10.82
24 - 35	10.633	0.066	10.503	10.762
36 - 47	10.804	0.082	10.643	10.965
48 - 59	11.000	0.105	10.794	11.206

Table 4.2.27 represents a pairwise comparison of child weight by child age. Mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.479, 95% CI: 0.291 to 0.666, $p < 0.05$), between less than 12 months and 24 - 35 months age group (M D = 0.521, 95% CI: 0.256 to 0.786, $p < 0.05$) and between less than 12 months and 36 - 47 months age group (M D = 0.350, 95% CI: 0.016 to 0.683, $p < 0.05$) is statistically significant. Mean difference of child weight between 12 – 23 months and 48 - 59 months age group (M D = -0.325, 95% CI: -0.580 to - 0.071, p-value < 0.05) is statistically significant. Mean difference of child weight between 24 - 35 months and 36 - 47 months age group (M D = -0.171, 95% CI: - 0.306 to - 0.036, $p < 0.01$), between 24 - 35 months and 48 - 59 months age group (M D = -0.368, 95% CI: -0.544 to - 0.191, $p < 0.05$) is statistically significant. Mean difference of child weight between 36 - 47 months and 48 -59 months age group (M D = -0.196, 95% CI: - 0.326 to - 0.067, $p < 0.05$) is statistically significant.

Table 4.2.27: Pairwise Comparison of Child Weight by Child Age

Dependent variable: Child Weight						
Child Age	Child Age	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
<12	12 - 23	0.479*	0.096	0.000	0.291	0.666
	24 - 35	0.521*	0.135	0.000	0.256	0.786
	36 - 47	0.350*	0.170	0.040	0.016	0.683
	48 - 59	0.153	0.200	0.442	-0.238	0.545
12 - 23	24 - 35	0.042	0.075	0.575	-0.105	0.190
	36 - 47	-0.129	0.103	0.208	-0.330	0.072
	48 - 59	-0.325*	0.130	0.012	-0.580	-0.071
24 - 35	36 - 47	-0.171*	0.069	0.013	-0.306	-0.036
	48 - 59	-0.368*	0.090	0.000	-0.544	-0.191
36 - 47	48 - 59	-0.196*	0.066	0.003	-0.326	-0.067
*Mean difference is significant at the .05 level.						

Table 4.2.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in the first birth order is around 10.9 kg. The mean weight of a child in the second birth order is around 10.8 kg. For third birth order, mean weight of a child is around 10.7 kg. Similarly, for 4 & above birth order, mean weight of a child is around 10.8 kg.

Table 4.2.28: Descriptive Statistics of Child Weight by Birth Order

Dependent Variable: Child Weight				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	10.969	0.060	10.852	11.086
2	10.854	0.060	10.737	10.972
3	10.777	0.067	10.646	10.907
4 & above	10.812	0.067	10.680	10.943

Table 4.2.29 represents a pairwise comparison of child weight by birth order. Mean difference of child weight between first and second birth order (M D = 0.114, 95% CI: 0.023 – 0.206, $p < 0.05$), between first and third birth order (M D = 0.192, 95% CI: 0.083 – 0.302, $p < 0.05$) and between first and 4 & above birth order (M D = 0.157, 95% CI: 0.044 – 0.270, $p < 0.05$) is statistically significant.

Table 4.2.29: Pairwise comparisons of Child Weight by birth order

Dependent variable: Child Weight						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
1	2	0.114*	0.047	0.015	0.023	0.206
	3	0.192*	0.056	0.001	0.083	0.302
	4 & above	0.157*	0.057	0.006	0.044	0.270
2	3	0.078	0.056	0.165	-0.032	0.188
	4 & above	0.043	0.057	0.455	-0.069	0.155
3	4 & above	-0.035	0.062	0.568	-0.156	0.086
* Mean difference is significant at the 0.05 level.						

Table 4.2.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 10.6 kg. For mothers with primary education, average weight of the child is around 10.8 kg. For mothers with secondary education, average weight of the child is around 10.9 kg. Similarly, for mothers with higher education, the average child's weight is around 11.2 kg.

Table 4.2.30: Descriptive Statistics of Child Weight by Educational Level

Dependent Variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	10.61	0.06	10.49	10.73
Primary	10.79	0.07	10.64	10.93
Secondary	10.86	0.06	10.75	10.97
Higher	11.16	0.10	10.97	11.35

Table 4.2.31 represents a pairwise comparison of child weight by educational level. Mean difference of child weight between mothers with no education and primary education (M D = - 0.173, 95% CI: - 0.292 to -0.055, p < 0.05), between mothers with no education and secondary education (M D = -0.245, 95% CI: -0.342 to -0.148, p < 0.05), between mothers with no education and higher education (M D = -

0.548, 95% CI: -0.746 to -0.351, p < 0.05) is statistically significant. Mean difference of child weight between mothers with primary and higher education (M D = -0.375, 95% CI: -0.585 to -0.165, p < 0.05) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.303, 95% CI: -0.484 to -0.122, p < 0.05) is statistically significant.

Table 4.2.31: Pairwise comparisons of Child Weight by educational level

Dependent variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No education	Primary	-0.173*	0.06	0.004	-0.292	-0.055
	Secondary	-0.245*	0.05	0.000	-0.342	-0.148
	Higher	-0.548*	0.101	0.000	-0.746	-0.351
Primary	Secondary	-0.072	0.062	0.250	-0.194	0.051
	Higher	-0.375*	0.107	0.000	-0.585	-0.165
Secondary	Higher	-0.303*	0.092	0.001	-0.484	-0.122
*Mean difference is significant at the 0.05 level.						

Table 4.2.32 represents the descriptive statistics of child weight by respondent occupation. Mean weight of the child for mothers with no occupation is around 10.9 kg. But, for mothers with other occupation and agricultural mothers, average weight of the child is around 10.8 kg.

Table 4.2.32: Descriptive statistics of Child Weight by respondent occupation

Dependent variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	10.911	0.048	10.816	11.005
Others	10.828	0.073	10.685	10.971
Agriculture	10.820	0.076	10.67	10.97

Table 4.2.33 represents a pairwise comparison of child weight by respondent occupation. Mean difference of child weight between mothers with no occupation and mothers with other occupation (M D = 0.083, 95% CI: -0.040 to 0.206, p = 0.187), between mothers with no occupation and agricultural mothers (M D = 0.091, 95% CI: - 0.033 to 0.214, p = 0.152) is statistically insignificant. Similarly, mean difference of

child weight between mothers with other occupation and agricultural mothers (M D = 0.008, 95% CI: -0.156 to 0.172, p = 0.925) is statistically insignificant.

Table 4.2.33: Pairwise comparisons of Child Weight by respondent occupation

Dependent variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p -value	95% CI	
					LL	UL
No Occupation	Others	0.083	0.063	0.187	-0.04	0.206
	Agriculture	0.091	0.063	0.152	-0.033	0.214
Others	Agriculture	0.008	0.083	0.925	-0.156	0.172

Table 4.2.34 represents the descriptive statistics of child weight by type of residence. Mean weight of child in urban as well as rural regions is around 10.8 kg.

Table 4.2.34: Descriptive statistics of Child Weight by type of residence

Dependent variable: Child Weight				
Type Of Residence	Mean	Std. Error	95%CI	
			LL	UL
Rural	10.849	0.056	10.74	10.959
Urban	10.857	0.065	10.729	10.985

Table 4.2.35 represents a pairwise comparison of child weight by type of residence. Mean difference of child weight between urban region and rural region (M D = 0.008, 95% CI: -0.106 to 0.121, p = 0.895) is statistically insignificant.

Table 4.2.35: Pairwise comparison of Child Weight by type of residence

Dependent variable: Child Weight						
Type of residence	Type of place of residence	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Urban	Rural	0.008	0.058	0.895	-0.106	0.121

Table 4.2.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.4 kg. In the poorer groups, children's average weight is around 10.6 kg. In the middle groups, children's average weight is around 10.9 kg. Similarly, in richer as well as richest groups, the average weight of children is around 11 kg and 11.3 kg, respectively.

Table 4.2.36: Descriptive statistics of Child Height by wealth index

Dependent variable: Child Weight				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.399	0.067	10.268	10.53
Poorer	10.612	0.068	10.477	10.746
Middle	10.910	0.072	10.769	11.051
Richer	11.001	0.08	10.845	11.157
Richest	11.342	0.103	11.14	11.544

Table 4.2.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest and poorer group (M D = -0.212, 95% CI: -0.31 to - 0.12, $p < 0.05$), between poorest group and middle group (M D = - 0.511, 95% CI: -0.63 to - 0.39, $p < 0.05$), between poorest group and richer group (M D = - 0.602, 95% CI: -0.77 to - 0.44, $p < 0.05$), and between poorest group and richest group (M D = - 0.943, 95% CI: -1.18 to - 0.71, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and middle group (M D = - 0.298, 95% CI: -0.42 to – 0.18, $p < 0.05$), between poorer group and richer group (M D = -0.390, 95% CI: -0.55 to – 0.23, $p < 0.05$), and between poorer group and richest group (M D = -0.731, 95% CI: -0.96 to – 0.50, $p < 0.05$) is statistically significantly. Mean difference of child weight between middle and richest group (M D = -0.432, 95% CI: - 0.66 to – 0.21, $p < 0.01$) is statistically significant. Mean difference of child weight between richer and richest group (M D = - 0.341, 95% CI: -0.57 to – 0.11, $p < 0.01$) is statistically significant.

Table 4.2.37: Pairwise comparison of Child Weight by wealth index

Dependent variable: Child Weight						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Poorest	Poorer	-0.212*	0.05	0.000	-0.31	-0.12
	Middle	-0.511*	0.06	0.000	-0.63	-0.39
	Richer	-0.602*	0.08	0.000	-0.77	-0.44
	Richest	-0.943*	0.12	0.000	-1.18	-0.71
Poorer	Middle	-0.298*	0.06	0.000	-0.42	-0.18
	Richer	-0.390*	0.08	0.000	-0.55	-0.23
	Richest	-0.731*	0.12	0.000	-0.96	-0.50
Middle	Richer	-0.091	0.08	0.270	-0.25	0.07
	Richest	-0.432*	0.12	0.000	-0.66	-0.21
Richer	Richest	-0.341*	0.12	0.003	-0.57	-0.11
*Mean difference is significant at the 0.05 level.						

Table 4.2.38 represents the descriptive statistics of Child Weight by BMI. The average weight of a child with a normal woman is around 10.5 kg. The average weight of child with underweight women is around 10.2 kg. The average weight of a child with an overweight woman is around 11.2 kg. Similarly, children's average weight in obese women is around 11.5 kg.

Table 4.2.38: Descriptive statistics of Child Weight by BMI

Dependent variable: Child Weight				
BMI (Kg/m^2)	Mean	Std. Error	95% CI	
			LL	UL
Normal	10.501	0.043	10.417	10.584
Underweight	10.218	0.051	10.118	10.317
Overweight	11.157	0.077	11.006	11.308
Obese	11.536	0.154	11.234	11.838

Table 4.2.39 represents a pairwise comparison of child weight by BMI. Mean difference of child weight between normal women and underweight women (M D = 0.283, 95% CI: 0.20 to 0.36, $p < 0.05$), between normal and overweight women (M D = - 0.656, 95% CI: -0.81 to - 0.51, $p < 0.05$) is statistically significant. Also, mean

difference of child weight between normal and obese women (M D = - 1.035, 95% CI: -1.34 to - 0.73, $p < 0.05$) is statistically significant. Mean difference of child weight between underweight and overweight women (M D = - 0.940, 95% CI: -1.10 to - 0.78, $p < 0.05$) and between underweight and obese women (M D = - 1.319, 95% CI: -1.63 to - 1.01, $p < 0.05$) is statistically significant. Mean difference of child weight between overweight and obese women (M D = - 0.379, 95% CI: -0.71 to - 0.05, $p < 0.05$) is statistically significant.

Table 4.2.39: Pairwise comparison of Child Weight by BMI

Dependent variable: Child Weight						
BMI (Kg/m^2)	BMI (Kg/m^2)	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Normal	Underweight	0.283*	0.04	0.000	0.20	0.36
	Overweight	-0.656*	0.08	0.000	-0.81	-0.51
	Obese	-1.035*	0.16	0.000	-1.34	-0.73
Underweight	Overweight	-0.940*	0.08	0.000	-1.10	-0.78
	Obese	-1.319*	0.16	0.000	-1.63	-1.01
Overweight	Obese	-.379*	0.17	0.023	-0.71	-0.05
*Mean difference is significant at the .05 level.						

Table 4.2.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 11.1 kg. Similarly, children's average weight in females is around 10.6 kg.

Table 4.2.40: Descriptive statistics of Child Weight by child sex

Dependent variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	11.093	0.06	10.98	11.20
Female	10.612	0.06	10.50	10.72

Table 4.2.41 represents a pairwise comparison of child weight by Child Sex. Mean difference of child weight between in male children and female children (M D = 0.481, 95% CI: 0.409 to 0.553, $p < 0.05$) is statistically significant.

Table 4.2.41: Pairwise comparison of Child Weight by child sex

Dependent variable: Child Weight						
Sex of child	Sex of child	Mean Difference	Std. Error	p -value	95% CI	
					LL	UL
Male	Female	0.481*	0.037	0.000	0.409	0.553
*Mean difference is significant at the 0.05 level.						

4.2.7 Growth Nomogram

Table 4.2.42: Under-5 children of different birth-weight categories by their socio-demographic characteristic in Eastern Region of India

Socio-demographic Characteristics		Birthweight (gm)								
		< 2000		2000 - 2499		2500 - 2999		3000 +		Total
		n_1	%	n_2	%	n_3	%	n_4	%	n
Child Age (Months)	**<12**	284	2.6	1020	9.5	3010	27.9	6472	60	10786
	12-23	295	3.1	938	9.8	2617	27.3	5728	59.8	9578
	24-35	249	2.5	930	9.3	2748	27.4	6087	60.8	10014
	36-47	242	2.3	884	8.4	2660	25.3	6716	63.9	10502
	48-59	260	2.6	754	7.5	2410	24.1	6585	65.8	10009
		Chi-square (df = 12) = 138.020, p < 0.001								
Sex of Child	**Boy**	713	2.5	2316	8.3	6923	24.7	18061	64.5	28013
	Girl	824	3.2	2482	9.5	6974	26.8	15782	60.6	26062
		Chi-square (df = 3) = 97.151, p < 0.001								
Birth Order	**1**	777	4.1	2059	11	5807	30.9	10126	54	18769
	2	389	2.5	1348	8.5	4275	27.1	9765	61.9	15777
	3	192	2	710	7.5	2102	22.3	6425	68.1	9429
	4 & above	179	1.8	681	6.7	1713	17	7527	74.5	10100
		Chi-square (df = 9) = 1403.64, p < 0.001								
BMI (kg/m^2)	**< 18.5**	562	3.4	1677	10	4393	26.3	10080	60.3	16712
	18.5 -24.9	825	2.6	2722	8.4	8204	25.4	20550	63.6	32301
	25.0 - 29.9	105	2.9	307	8.3	964	26.2	2304	62.6	3680
	≥ 30	28	3.5	53	6.7	205	26	503	63.8	789
		Chi-square (df = 9) = 87.723, p < 0.001								
Highest Educational Level	**No Education**	516	2.2	1768	7.5	4646	19.7	16694	70.7	23624
	Primary	233	3.1	715	9.5	2013	26.8	4542	60.5	7503
	Secondary	692	3.4	2080	10.3	6413	31.6	11085	54.7	20270
	Higher	96	3.6	235	8.8	825	30.8	1522	56.8	2678
		Chi-square (df = 9) = 1276.732, p < 0.001								
Respondent's Occupation	**No Occupation**	207	3	625	9	1855	26.6	4291	61.5	6978
	Others	28	3.2	89	10.1	229	26.1	531	60.5	877
	Agriculture	17	1.9	80	8.8	214	23.6	595	65.7	906
	Don't Know	2	2	8	7.9	23	22.8	68	67.3	101
		Chi-square (df = 9) = 11.531, p < 0.001								
Place of Residence	**Urban**	272	3.5	771	9.8	2462	31.3	4349	55.4	7854
	Rural	1265	2.7	4027	8.7	11435	24.7	29494	63.8	46221
		Chi-square (df = 3) = 212.092, p < 0.001								
Wealth Index	**Poorest**	648	2.4	2162	8.1	5746	21.6	18085	67.9	26641
	Poorer	427	3.2	1309	9.7	3739	27.8	7982	59.3	13457
	Middle	236	3.1	703	9.3	2362	31.3	4256	56.3	7557
	Richer	155	3.5	463	10.4	1417	31.8	2421	54.3	4456
	Richest	71	3.6	161	8.2	633	32.2	1099	56	1964
		Chi-square (df = 12) = 715.770, p < 0.001								

Birth weight by sociodemographic characteristics

The distribution of children under the age of five is shown in Table 1 by their birth weight and eight sociodemographic factors, including the child's age, sex, birth order, body mass index (BMI), respondents' highest educational level, respondents' occupation, respondents' place of residence, and wealth index. Our study found that seven out of eight sociodemographic factors and birthweight were strongly correlated. Thus, birth weight had an association with the age of child ($\chi^2 = 138.02, d.f. = 12, p < 0.001$), sex of child ($\chi^2 = 97.15, d.f. = 3, p < 0.001$) and birth order ($\chi^2 = 1403.64, d.f. = 9, p < 0.001$). BMI was also found to be significantly associated ($\chi^2 = 87.72, d.f. = 9, p < 0.001$) with birth weight. When mothers' highest education level and children's birth weight were taken into consideration, our analysis again revealed a strong association between the two factors ($\chi^2 = 1276.73, d.f. = 9, p < 0.001$). The analysis demonstrated that respondents' two factors – a place of residence and wealth index – also play a role in the determination of children's birthweight. This is due to the fact that respondents' place of residence ($\chi^2 = 212.09, d.f. = 3, p < 0.001$) and wealth index ($\chi^2 = 715.77, d.f. = 12, p < 0.001$) also showed a high correlation with children's birthweight. Only one factor, respondents' occupation ($\chi^2 = 11.53, d.f. = 9, p = 0.241$), failed to demonstrate any correlation with children's birth weight.

4.2.7.1 Growth Prediction of Under-5 Children Using Statistical Models

As stated in the Methods Section, only *Cubic Model* and *Power Model* offered the best fit to the height and weight measurements. As a result, only the findings of the two best-fit models have been displayed here in order to predict growth using height and weight curves [Tables 4.2.43 and 4.2.44].

Table 4.2.43 describes model's summary for estimating height of boys and girls separately by birth weight. Here, for height of boys, *Power Model* showed best fit for the birth-weight group < 2000 gm ($R^2 = 0.794$) but for the rest of three birth-weight groups, *Cubic Model* was the best fit model. As a result, *Cubic Model* demonstrated the best fit ($R^2 = 0.805$) for the birthweight range of 2500–2999 g, followed by 2000–2499 g ($R^2 = 0.787$) and then, 3000 g and beyond ($R^2 = 0.776$). In a similar manner, for girls' height, *Power model* once more shown best match for the birth weight group < 2000 gm ($R^2 = 0.820$), however for the other 3 birth weight groups, the Cubic Model was the best fit model. Thus, 2000–2499 g ($R^2 = 0.795$) birth-weight range, followed by the 2500–2999 g ($R^2 = 0.788$), and the 3000 g and above ($R^2 = 0.757$), demonstrated the best fit for the Cubic Model.

Table 4.2.43: Model's summary for Height of Boys & Girls by their Birthweight categories: NFHS - 4 (2015-16)

Birthweight	Model	R^2	Constant	d.f.		f	b_1	b_2	b_3
				Regression	Residuals				
Boys									
< 2000	Power	0.794	45.357	1	580	2236.6	0.186		
2000 - 2499	Cubic	0.787	53.988	3	2110	2600.1	1.766	-0.33	0.0002
2500 - 2999	Cubic	0.805	54.833	3	6505	8934.3	1.701	-0.029	0.0002
3000 +	Cubic	0.776	56.535	3	16343	18908.8	1.586	-0.027	0.0002
Girls									
< 2000	Power	0.820	44.030	1	707	3228.2	0.190		
2000 - 2499	Cubic	0.795	53.413	3	2265	2936.4	1.666	-0.029	0.0002
2500 - 2999	Cubic	0.788	54.647	3	6557	8146.1	1.588	-0.025	0.0001
3000 +	Cubic	0.757	55.537	3	14329	14846.3	1.530	-0.025	0.0001

Table 4.2.44 describes model's summary for estimating weight of boys and girls separately by birth weights. *Power Model* was the best-fit model for both girls' and boys' weight. In addition, when it came to boys, this model was most appropriate

for the birth-weight range of 2500–2999 g ($R^2 = 0.768$), followed by 2000–2499 g ($R^2 = 0.750$), < 2000 g ($R^2 = 0.746$), and finally 3000 g and above ($R^2 = 0.733$). In terms of estimating weight for girls, *Power Model* indicated that birth weight groups below 2000 g ($R^2 = 0.785$), between 2500 and 2999 g ($R^2 = 0.764$), between 2000 and 2499 g ($R^2 = 0.762$), and above 3000 g ($R^2 = 0.726$) provided the best fit.

Table 4.2.44: Model's summary for Weight of Boys & Girls by Birthweight categories: NFHS - 4 (2015-16)

Birthweight	Model	R^2	Constant	d.f.		f	b_1
Boys				**Regression**	**Residuals**		
< 2000	Power	0.746	2742.468	1	581	1709.032	0.393
2000 - 2499	Power	0.750	3276.688	1	2115	6337.666	0.345
2500 - 2999	Power	0.768	3430.093	1	6515	21606.757	0.339
3000 +	Power	0.733	3747.194	1	16356	44832.622	0.316
Girls							
< 2000	Power	0.785	2546.490	1	707	2573.891	0.396
2000 - 2499	Power	0.762	3066.895	1	2268	7255.047	0.350
2500 - 2999	Power	0.764	3277.480	1	6566	21286.691	0.338
3000 +	Power	0.726	3391.454	1	14335	38065.486	0.329

4.2.7.2 Estimated Mean Height and Weight Curves and Their 95% Confidence Intervals

Using all 4 birth-weight categories and either Cubic or Power Models, depending on which one fits best, we generated growth values for boys and girls separately based on the mean height and weight of under 5 children for ages ranging from 1 to 59 months. Considering all four birth-weight groups, separate mean height, and weight curves for the two sexes were subsequently produced. Boys' estimated mean height and weight curves for each of the four birth weight categories are shown in *Figures 4.2.5(a) to (d).* In the same way, estimated mean height and weight curves for girls for each of the four birth weight groups are displayed in *Figures 4.2.6 (a) to (d).* The plots not only show predicted curves for mean height and weight but also 95 % upper and lower bounds. Therefore, it is possible to determine the expected average growth values for under-5-year-old children in terms of their mean height and mean weight for their ages, as well as their respective 95 percent upper and lower bounds, using the curves of *Figures 4.2.5 (a) to (b)* and *Figures 4.2.6 (a) to (b).*

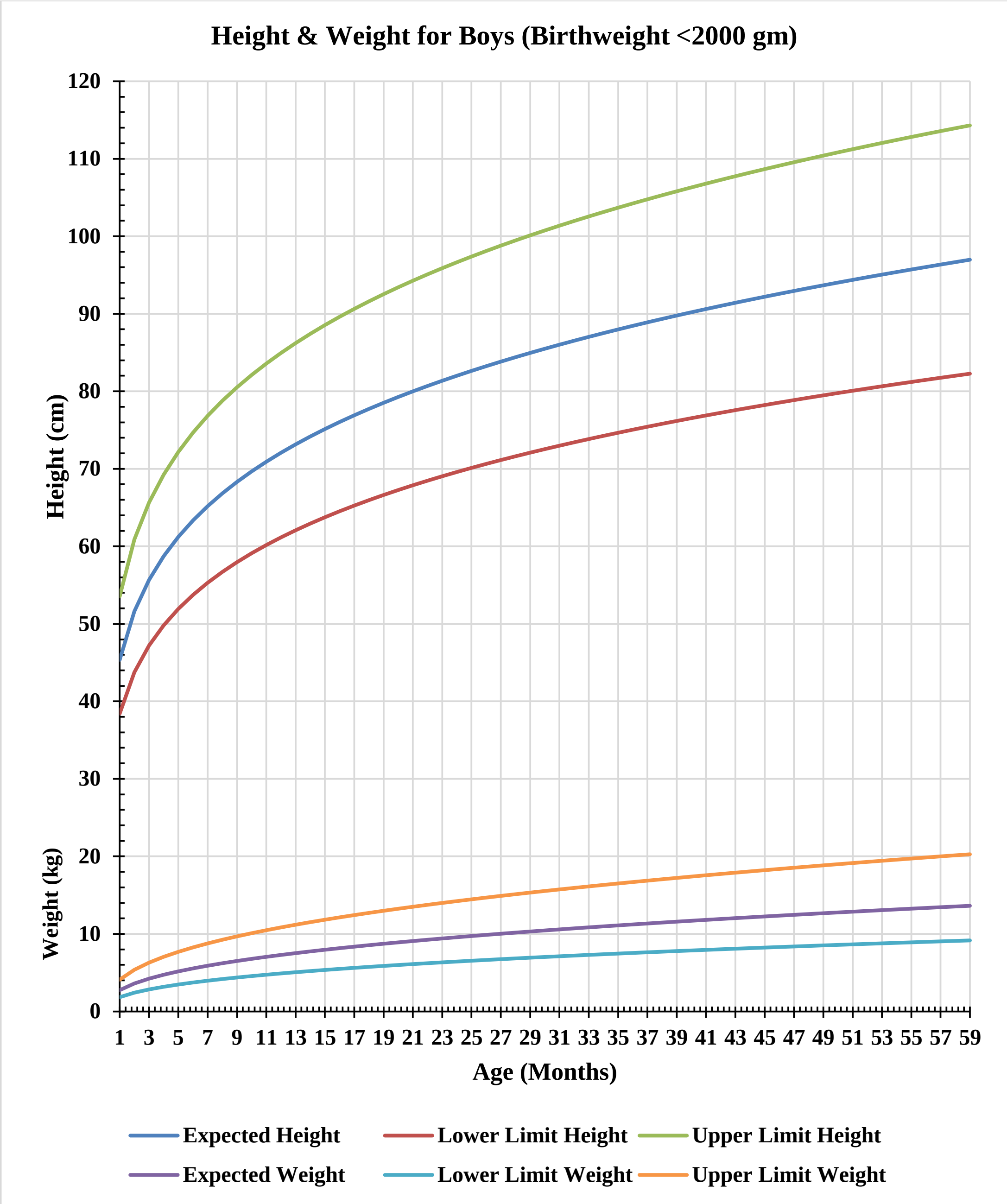
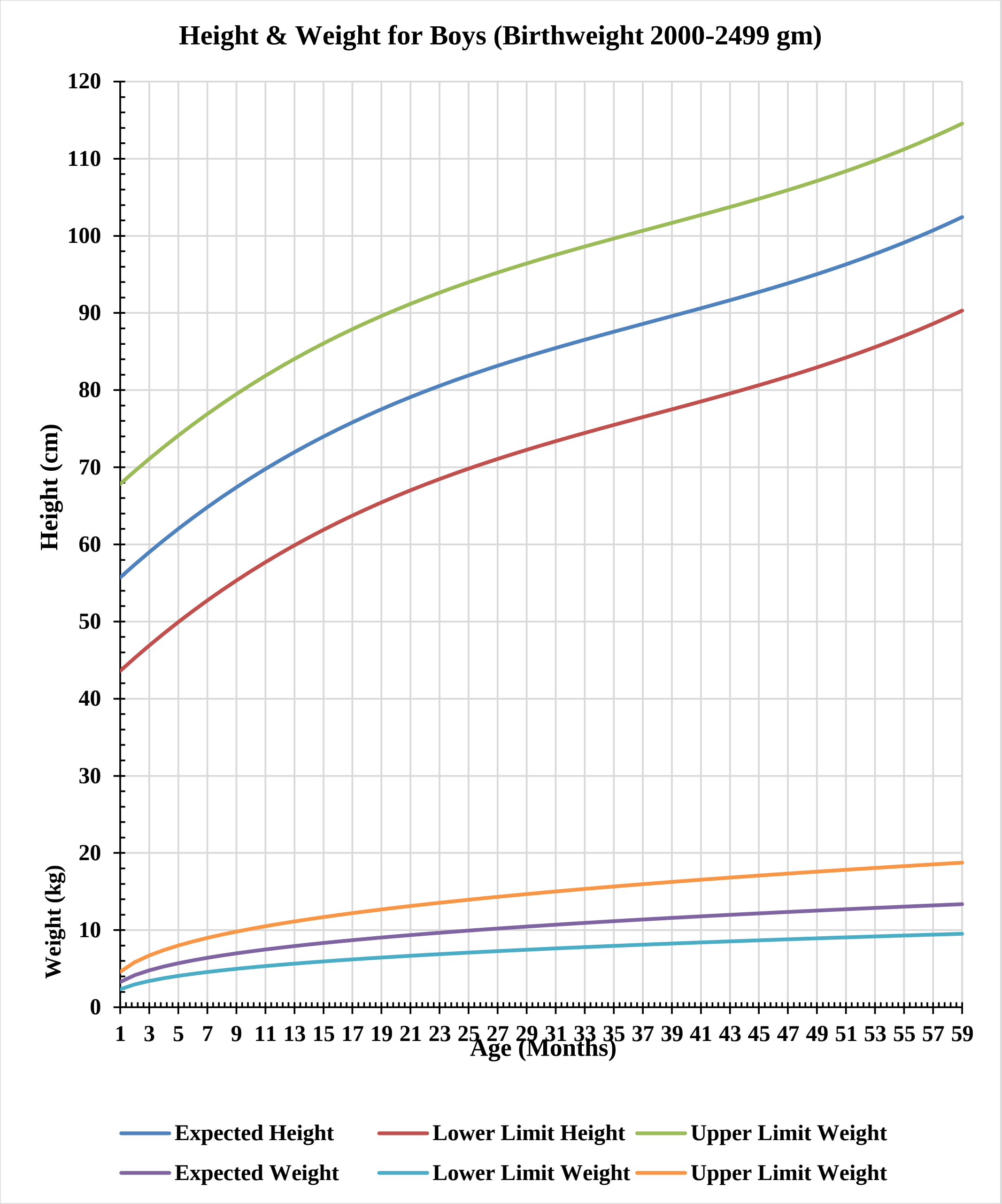


Figure 4.2.5 (a): NFHS – 4 (Birth-weight < 2000 gm): Estimated Height & Weight Curves for Boys of Eastern Region, Using Power Model



$Figure$ 4.2.5 (b): NFHS-4 (Birthweight 2000 – 2499 gm): Estimated Height and Weight Curves for Boys of East Region (India), using Cubic and Power Models, respectively.

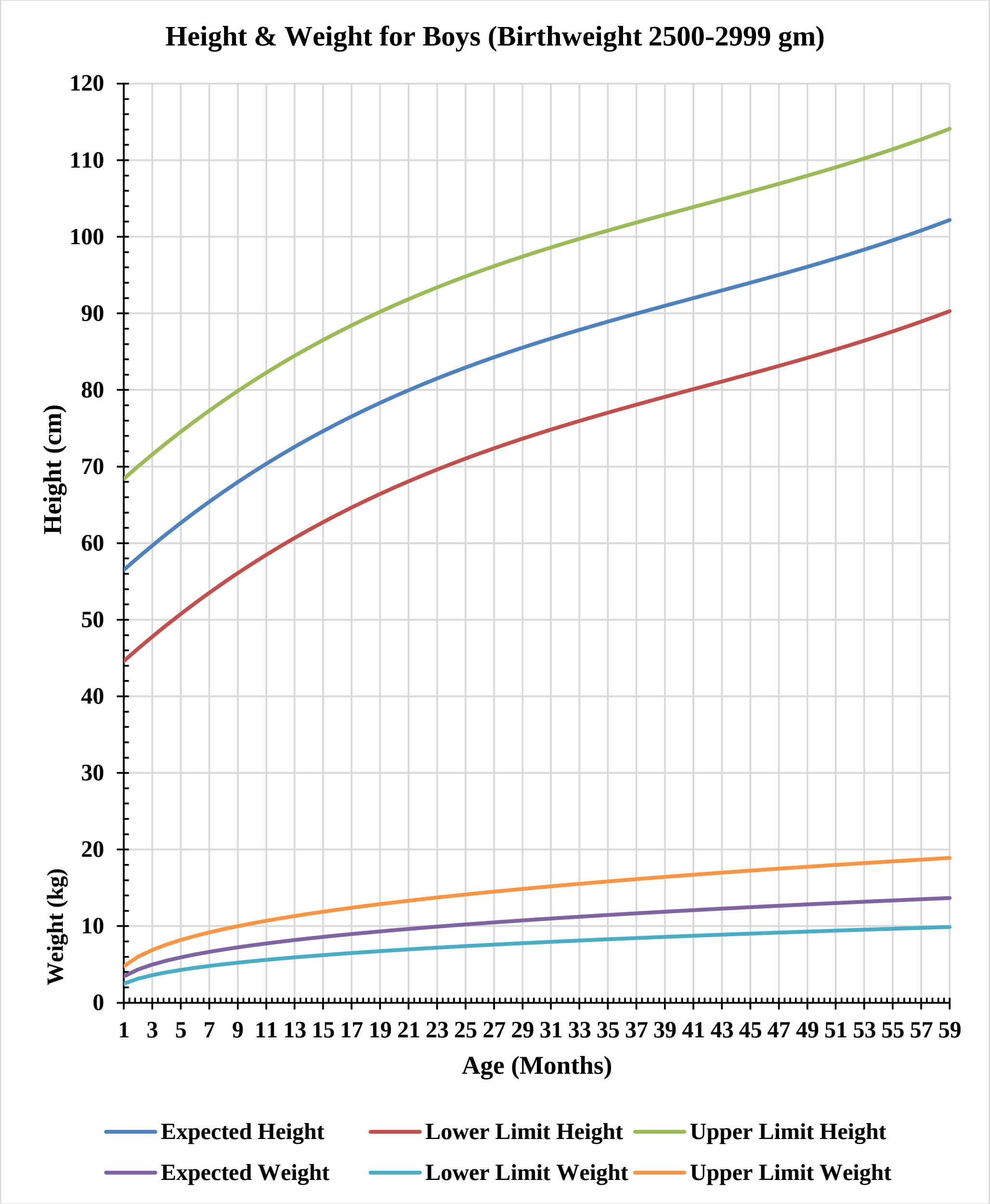
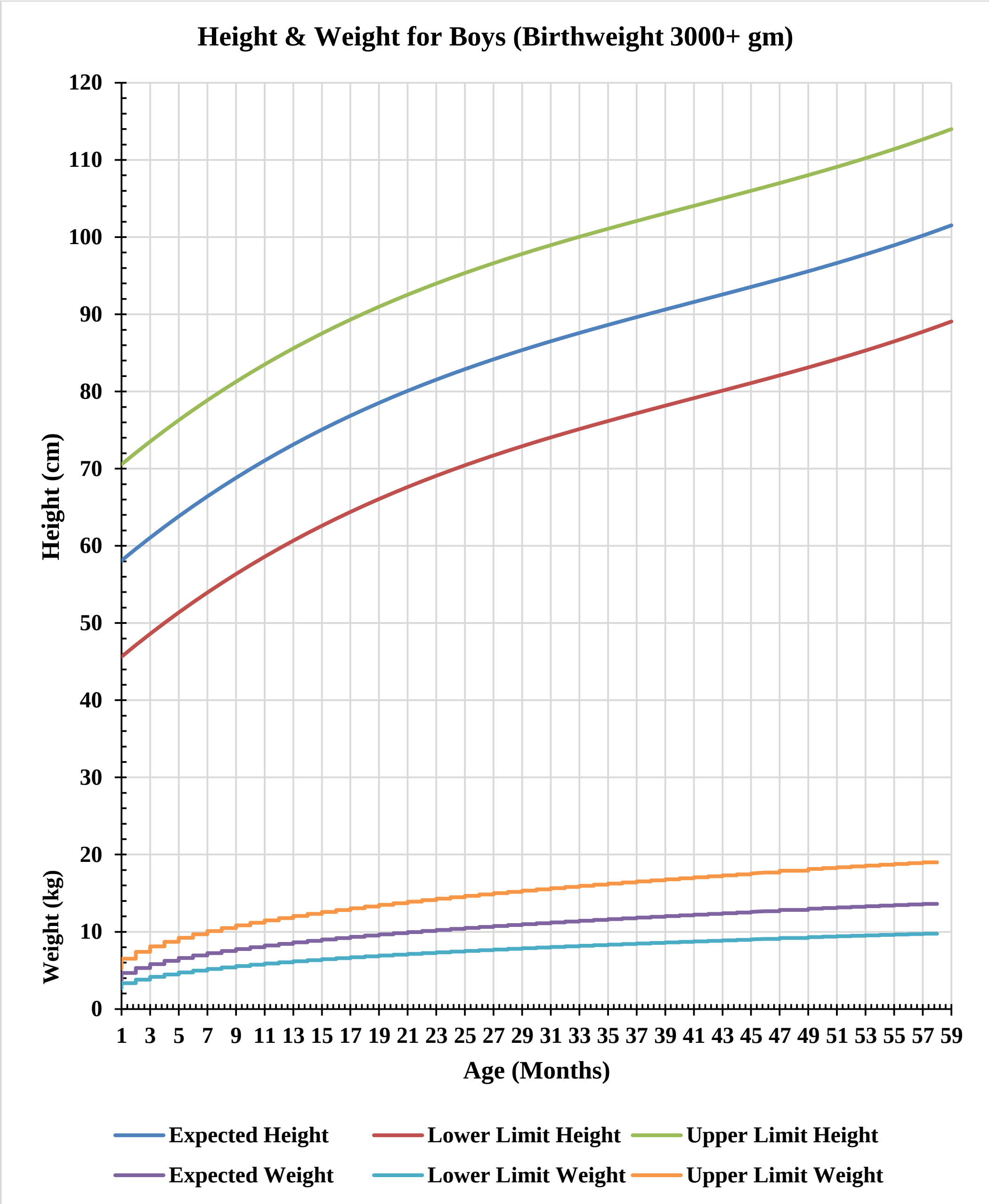


Figure 4.2.5 (c): NFHS-4 (Birth-weight 2500 – 2999 gm): Estimated Height and Weight Curves for Boys of East Region (India), using Cubic and Power Models, respectively.



$Figure$ 4.2.5 (d): NFHS-4 (Birth-weight 3000+ gm): Estimated Height and Weight Curves for Boys of East Region (India), using Cubic and Power Models, respectively.

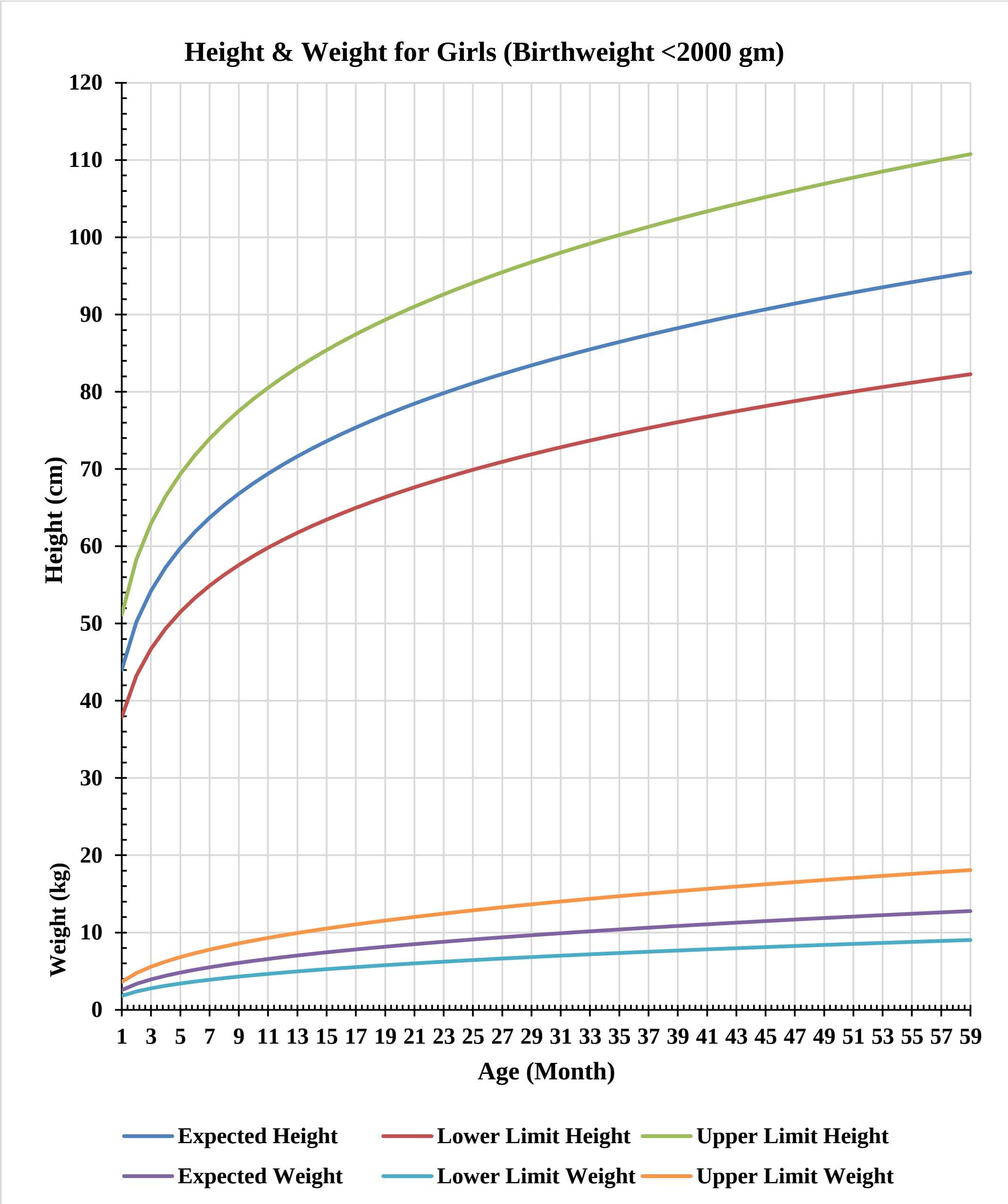
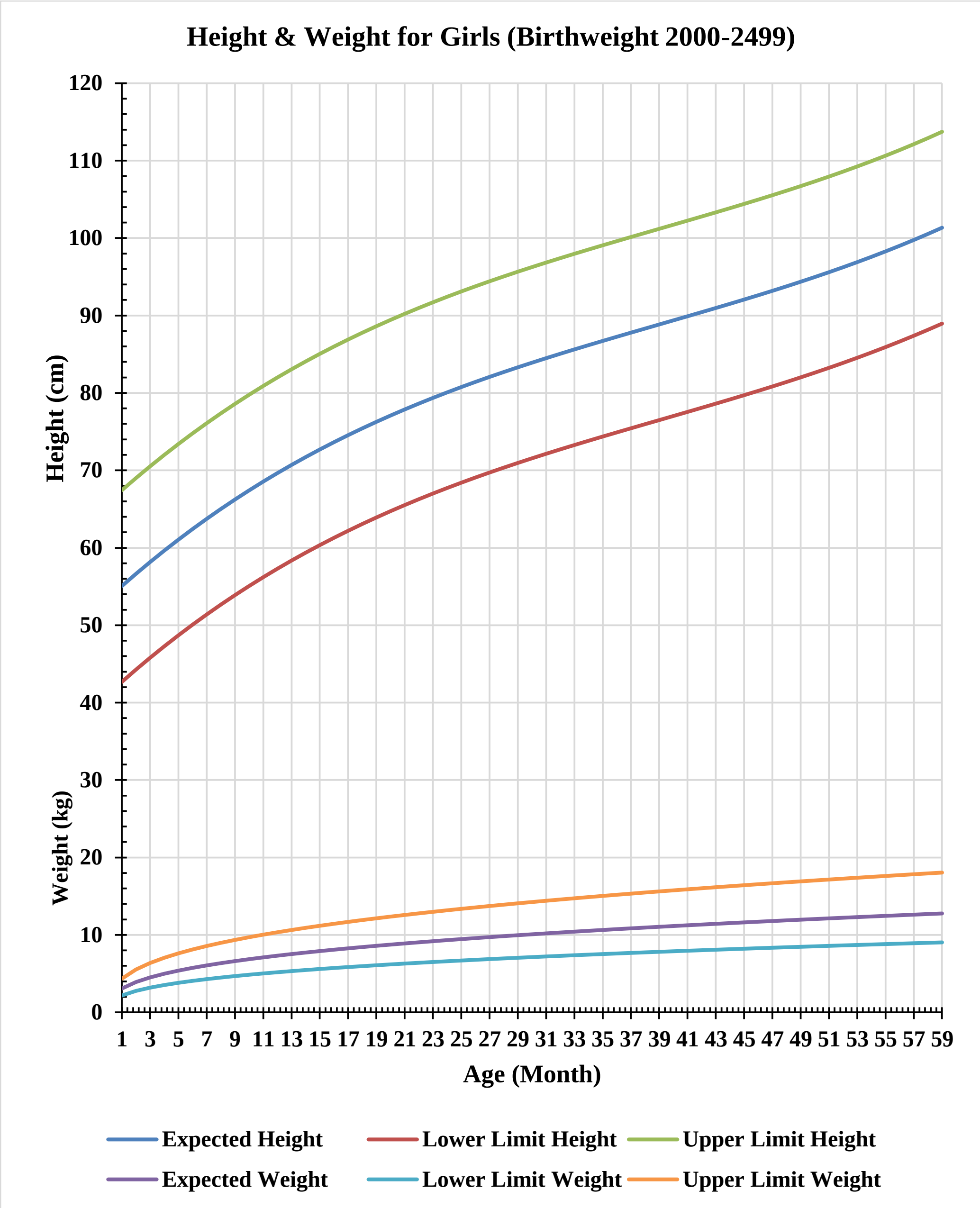
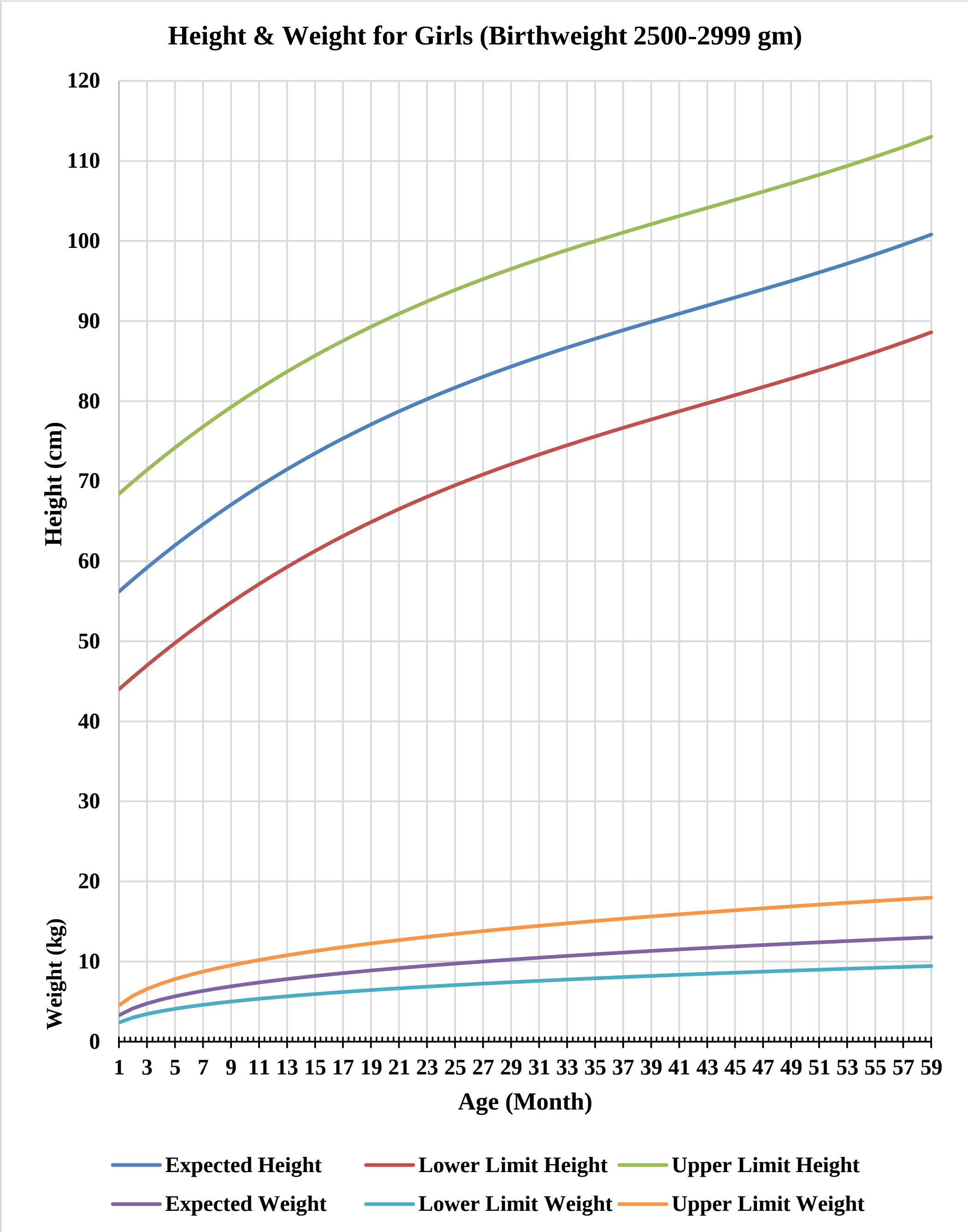


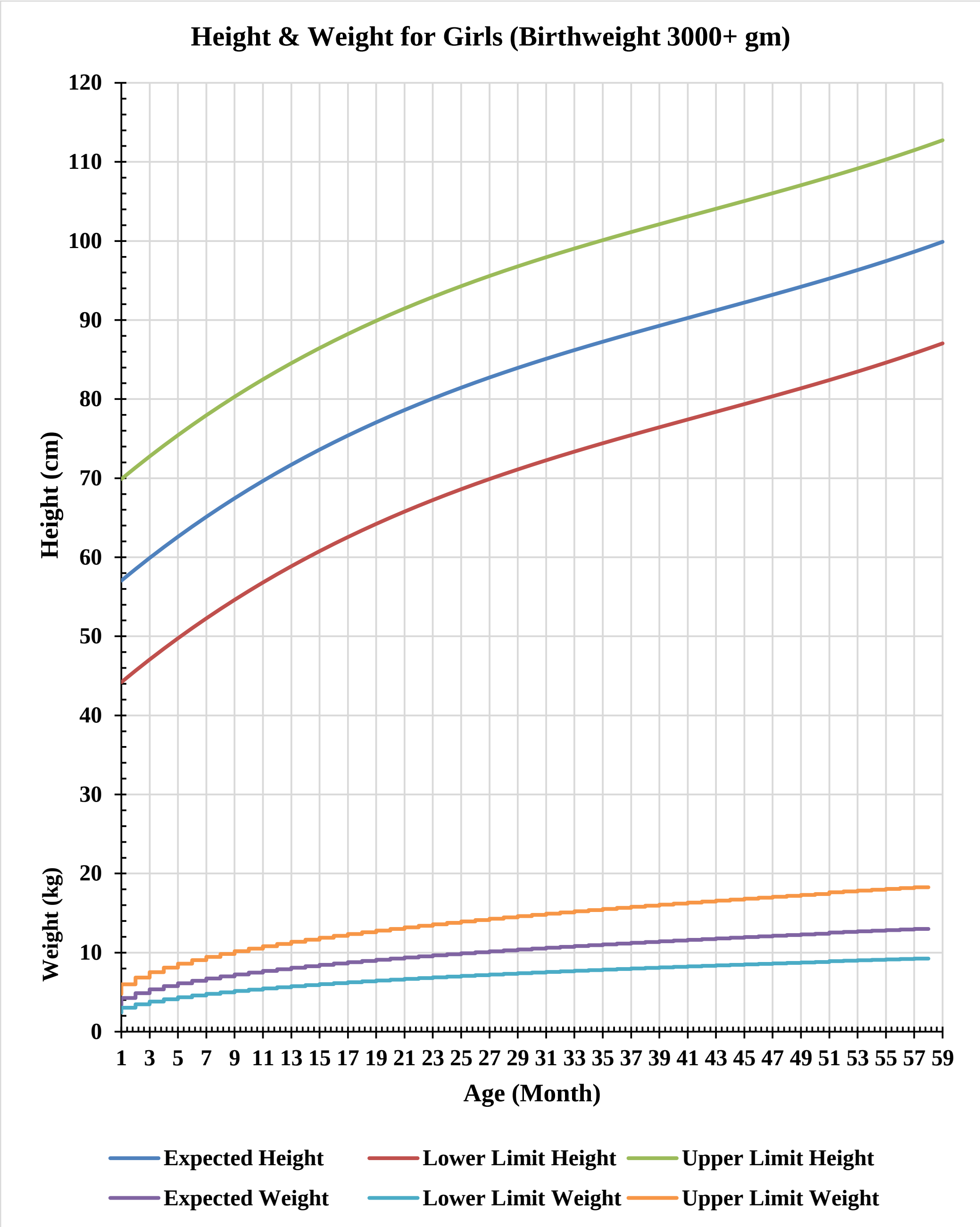
Figure 4.2.6(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height and Weight Curves for Girls of East Region (India), using Power Model.



$Figure\ 4.2.6(b)$: NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height and Weight Curves for Girls of East Region (India), using Cubic and Power Model.



$Figure$ 4.2.6(c): NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height and Weight Curves for Girls of East Region (India), using Cubic and Power Model, respectively



$Figure\ 4.2.6(d)$: NFHS-4 (Birth-weight 3000+ gm): Estimated Height and Weight Curves for Girls of East Region (India), using Cubic and Power Model, respectively

4.3 Northeast Region

This region consists of 8 regions: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura.

4.3.1 Status of Under-Nutrition

Table 4.3.1: Prevalence rate (%) of stunting, wasting and underweight

Northeast Region	Stunting	Wasting	Underweight
	28.6	**11.3**	**18.4**
Arunachal Pradesh	29.3	17.3	19.4
Assam	36.4	17.0	29.8
Manipur	28.9	6.8	13.8
Meghalaya	43.8	15.3	28.9
Mizoram	28.1	6.1	12.0
Nagaland	28.6	11.3	16.7
Sikkim	29.6	14.2	14.2
Tripura	24.3	16.8	24.1

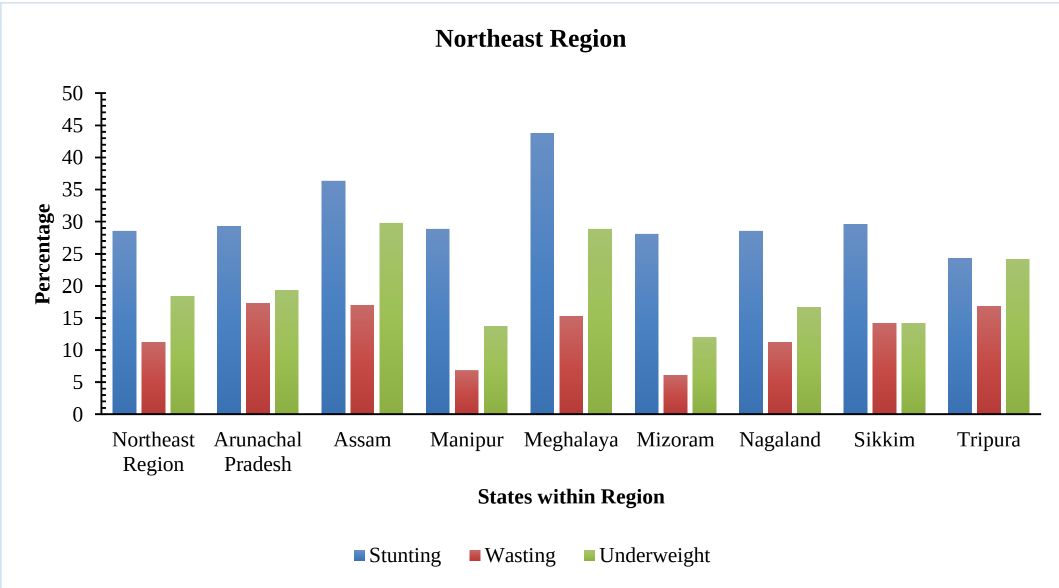


Figure 4.3.1: Prevalence rate (%) of stunting, wasting and underweight

Table 4.3.1 and figure 4.3.1 shows prevalence rates of stunting, wasting and underweight in Northeast Region. Stunting ranges from 29.3% (Arunachal Pradesh) to 24.3% (Tripura). Wasting was highest (17.3%) in Arunachal Pradesh and lowest (6.1%) in Mizoram. Prevalence of underweight was highest (29.8%) in Assam and lowest (12.0%) in Mizoram.

4.3.2 Stunting

Table 4.3.2: - Odd Ratio of Stunting in Under-5 Children by socio-demographic variables in the Northeast Region of India

Socio-demographic Variables	**p-value**	**OR**	**95% C.I. for OR**	
			Lower Limit	**Upper Limit**
Child Age (Month)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.70	2.48	2.94
24 - 35	0.000	2.45	2.25	2.67
36 - 47	0.000	3.08	2.83	3.35
48 - 59	0.000	2.77	2.55	3.01
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.18	1.13	1.24
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.24	1.95	2.58
Poorer	0.000	1.84	1.61	2.09
Middle	0.000	1.56	1.37	1.77
Richer	0.222	1.09	0.95	1.24
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.43	1.24	1.64
Primary	0.000	1.56	1.36	1.78
Secondary	0.000	1.26	1.11	1.42
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	1.14	1.06	1.22
Birth Order				
1 *(Ref)*		1.00		
2	0.000	1.13	1.06	1.20
3	0.000	1.17	1.09	1.26
4 & above	0.000	1.43	1.33	1.53
BMI (Kg/m^2)				
Normal *(Ref)*		1.00		
Underweight	0.000	1.34	1.26	1.44
Overweight	0.000	0.79	0.73	0.86
Obese	0.000	0.60	0.49	0.74

Table 4.3.2 shows odds ratio of stunting in children under the age of five by socio-demographic variables in Northeast of India. When compared to children below 12 months, the odds of a children being stunted was 2.7 times higher in the 12 to 23 month age group (OR: 2.70; 95% CI: 2.48 – 2.94; p < 0.001). When compared to children under the age of 12 months, the odds of a children being stunted were 2.4 times higher in the age group of 24 to 35 months (OR: 2.45; 95% CI: 2.25 – 2.67; p < 0.001). When compared to children under the age of 12 months, the odds of a child being stunted were 3.1 times higher for children aged 36 to 47 months (OR: 3.08; 95% CI: 2.83 – 3.35; p < 0.001). The odds of a children being stunted was 2.7 times higher in the 48 - 59 month age group (OR: 2.77; 95% CI: 2.55 – 3.01; p < 0.001) when compared to children under the age of 12 months. In comparison to female children, male children (OR: 1.18; 95% CI: 1.13 – 1.24; p < 0.001) had significantly higher odds of stunting.

The odds of a children being stunted was 2.2 times higher in the poorest group (OR: 2.24; 95% CI: 1.95 – 2.58; p < 0.001) when compared to the richest group. The odds of a children being stunted was 1.8 times higher in the poorer group (OR: 1.84; 95% CI: 1.61 – 2.09; p < 0.001) when compared to the richest group. The odds of a children being stunted was 1.5 times higher in the middle group (OR: 1.56; 95% CI: 1.37 – 1.77; p < 0.001) as compared to the richest group. The odds of a children being stunted was 1.1 times higher in the richer group (OR: 1.09; 95% CI: 0.95 – 1.24; p < 0.001) as compared to the richest group. There is no significant difference in the likelihood of stunting of children in the richer group as compared to richest group.

Mother with no education (OR: 1.43; 95% CI: 1.24 – 1.64; p < 0.001) had 1.4 times higher odds of having stunted children than mother with higher levels of education. Mother with only primary education (OR: 1.56; 95% CI: 1.36 – 1.78; p < 0.001) had

1.5 times higher odds of having children who are stunted than Mother with higher levels of education. Mother with secondary education (OR: 1.26; 95% CI: 1.11 – 1.42; $p < 0.001$) had 1.2 times greater odds of having stunted children than mother with higher education levels. In comparison to urban regions, the odds of a children being stunted were significantly higher in rural areas (OR: 1.14; 95% CI: 1.06 – 1.22; $p < 0.001$).

The odds of having stunted children were significantly higher in the second birth order (OR: 1.13; 95% CI: 1.06 – 1.20; $p < 0.001$) as compare to first birth order. In comparison to first birth order, the odds of a children being stunted were 1.2 times higher in the third birth order OR: 1.17; 95% CI: 1.09 – 1.26; $p < 0.001$). The odds of having stunted children were 1.4 times greater in the birth order of 4 and above (OR: 1.43; 95% CI: 1.33 – 1.53; $p < 0.001$) compared to the first birth order. Mothers who were underweight (OR: 1.34; 95% CI: 1.26 – 1.44; $p < 0.001$) had 1.3 times greater odds of having stunted children than normal mother. Mothers with an overweight (OR: 0.79; 95% CI: 0.73 – 0.86; $p < 0.001$) had 21% lower odds of having children who were stunted than normal mothers. Obese mothers (OR: 0.60; 95% CI: 0.49 – 0.74; $p < 0.001$) had 40% lower odds of having stunted children than normal mothers.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model is 61.8% as shown in Table 4.3.3. However, depending on the demands of the study and the requirement for diagnostic research, sensitivity and specificity might be altered. Area under the ROC curve is 0.661 (95% CI: 0.655 – 0.667) (figure 4.3.2).

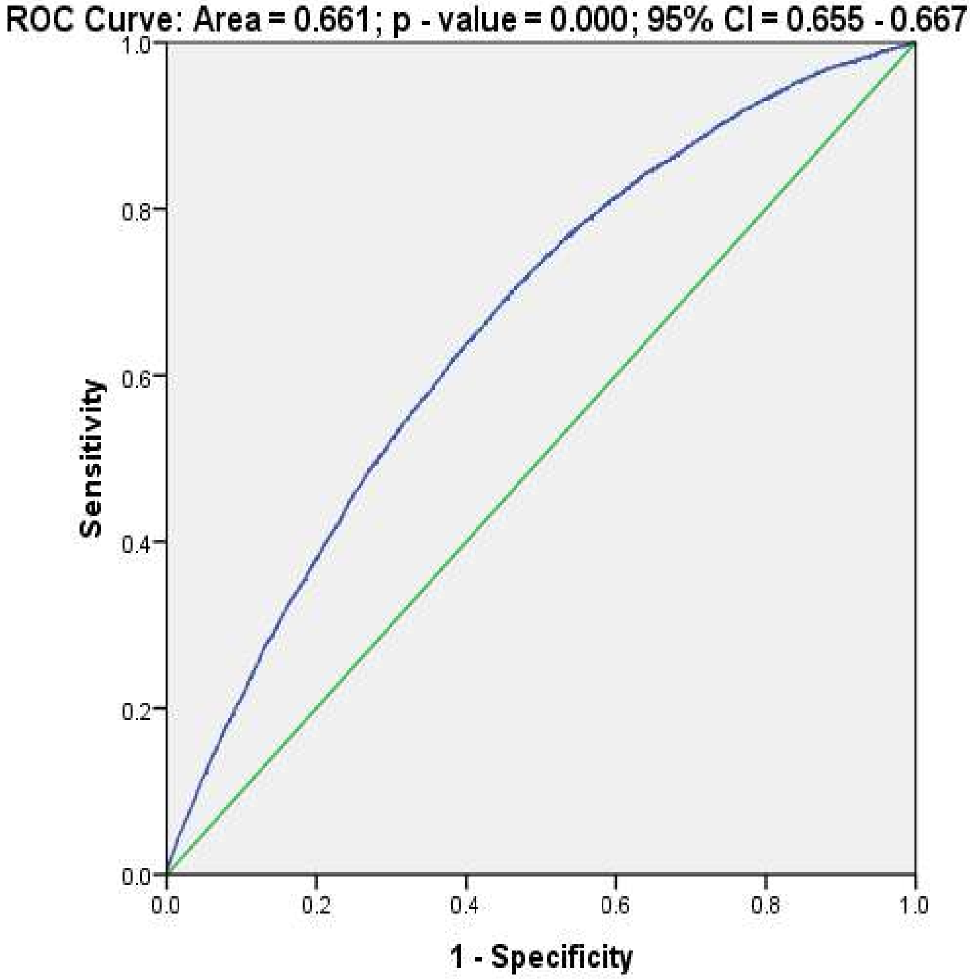


Figure. 4.3.2: - Receiving Operating Characteristic Curve highlighting the results for Stunting in the Northeast Region of India

Table 4.3.3: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.1553980	0.969	0.115
0.1711986	0.959	0.141
0.1781505	0.947	0.169
0.1858476	0.939	0.185
0.1960437	0.928	0.211
0.2020566	0.919	0.228
0.2079959	0.909	0.244
0.2203429	0.889	0.279
0.2269855	0.879	0.296
0.2318528	0.869	0.312
0.2370445	0.859	0.327
0.2447890	0.849	0.345
0.2511796	0.839	0.365
0.2561792	0.829	0.379
0.2604864	0.819	0.391
0.2669382	0.809	0.408
0.2746751	0.799	0.420
0.2796812	0.789	0.434
0.2847070	0.779	0.449
0.2929400	0.769	0.462
0.2969948	0.759	0.473
0.3014253	0.748	0.487
0.3080099	0.739	0.497
0.3101439	0.728	0.509
0.3144092	0.719	0.518
0.3215529	0.707	0.532
0.3267059	0.698	0.541
0.3302649	0.689	0.550
0.3320835	0.676	0.562
0.3351493	0.669	0.568
0.3366911	0.658	0.578
0.3386220	0.649	0.588
0.3465423	0.639	0.599
0.3486749	0.629	0.607
0.3544922	0.619	0.617
0.3556646	**0.618**	**0.618**
0.3910404	0.497	0.721
0.4007238	0.458	0.749
0.4281255	0.368	0.807
0.4841239	0.183	0.917
0.4928375	0.156	0.931

4.3.3 Wasting

Table 4.3.4: - Odds Ratio of Wasting in Under-5 Children by socio-demographic variables in Northeast Region of India

Socio - demographic Variables	**p - value**	**OR**	**95% C.I. for OR**	
			Lower Limit	**Upper Limit**
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	0.81	0.73	0.90
24 - 35	0.355	0.95	0.86	1.05
36 - 47	0.000	0.76	0.69	0.85
48 - 59	0.000	0.73	0.66	0.81
Child Sex				
Female *(Ref)*		1.00		
Male	0.002	1.11	1.04	1.19
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	**1.80**	1.48	2.20
Poorer	0.000	1.62	1.34	1.95
Middle	0.000	1.48	1.23	1.78
Richer	0.004	1.32	1.09	1.59
Highest Educational Level				
Higher *(Ref)*		1.00		
No Education	0.000	**1.47**	1.22	1.78
Primary	0.057	1.20	1.00	1.44
Secondary	0.145	1.13	0.96	1.34
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.013	1.13	1.03	1.25
Birth Order				
1 *(Ref)*		1.00		
2	0.173	0.94	0.87	1.03
3	0.046	**1.10**	1.00	1.22
4 & above	0.201	0.94	0.85	1.03
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	**1.37**	1.26	1.50
Overweight	0.000	0.81	0.73	0.91
Obese	0.001	0.58	0.42	0.81

Table 4.3.4 represents odds ratio of Wasting in Under-5 Children by socio-demographic variables in the Northeast Region of India. The odds of having wasted children was 19% lower in the age group 12 to 23 months (OR: 0.81; 95% CI: 0.73 – 0.90; p < 0.001) compared to the age group under 12 months. The odds of having wasted children were 5% lower in the age group of 24 to 35 months (OR: 0.95; 95% CI: 0.86 – 1.05; p = 0.355) compared to the age group under 12 months. There is no significant difference in the likelihood of wasted children in the 24-to-35-month age group as compared to children less than 12 months of age. The odds of having wasted children were 24% lower in the age group 36–47 months (OR: 0.76; 95% CI: 0.69 – 0.85; p < 0.001) compared to the age group below 12 months. The odds of having wasted children were 27% lower in the age group of 48 to 59 months (OR: 0.73; 95% CI: 0.66 – 0.81; p < 0.001) compared to the age group under 12 months. As comparison to female children, male children (OR: 1.11; 95% CI: 1.04 – 1.19; p < 0.001) had significantly greater odds of being wasted.

The odds of having wasted children were 1.8 times higher for the poorest group (OR: 1.80; 95% CI: 1.48 – 2.20; p < 0.001) compared to the richest group. In comparison to the richest group, the odds of having wasted children were 1.6 times higher for the poorer group (OR: 1.62; 95% CI: 1.34 – 1.95; p < 0.001)**.** In comparison to the richest group, the middle group (OR: 1.48; 95% CI: 1.23 – 1.78; p < 0.001) had 1.4 times higher odds of having wasted children. In comparison to the richest group, the odds of having wasted children were 1.3 times higher in the richer group (OR: 1.32; 95% CI: 1.09 – 1.59; p < 0.001).

In comparison to women with higher levels of education, mothers with no education (OR: 1.47; 95% CI: 1.22 – 1.78; p < 0.001) had 1.4 times greater odds of having wasted children. Mothers with primary education (OR: 1.20; 95% CI: 1.00 – 1.44; p = 0.057) had 1.2 times higher odds of having wasted children than those with higher levels of education. Mothers with secondary education (OR: 1.13; 95% CI: 0.96 – 1.34; p = 0.145) had significantly higher odds of having wasted children than those with higher degrees of education. There is no significant difference in the likelihood of wasting children for the mothers with primary education as well as mothers with secondary education.

In comparison to urban areas, rural areas (OR: 1.13; 95% CI: 1.03 – 1.25; p = 0.013) had significantly higher odds of having wasted children. The odds of having wasted children was 6% lower in the second birth order (OR: 0.94; 95% CI: 0.87 – 1.03; p = 0.173) as well as birth order of 4 and above (OR: 0.94; 95% CI: 0.85 – 1.03; p = 0.201) as compared to the first birth order. There is no significant difference in the likelihood of wasted children in the second birth order and birth order of 4 and above as compared to the first birth order. The odds of having wasted children was 1.1 times higher for third birth order (OR: 1.10; 95% CI: 1.00 – 1.2; p = 0.046) as compared to the first order. There is no significant difference in the likelihood of wasted children in the third birth order as compared to the first birth order.

In comparison to normal mothers, underweight mothers (OR: 1.37; 95% CI: 1.26 – 1.50; p < 0.001) had 1.3 times higher odds of having wasted children. When compared to normal mothers, overweight mothers (OR: 0.81; 95% CI: 0.73 – 0.91; p < 0.001) had 19% lower odds of having wasted children. As compared to normal mothers, obese mothers (OR: 0.58; 95% CI: 0.42 – 0.81; $p < 0.001$) had 42% lesser odds of having wasted children.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model are shown in Table 4.3.5 as 57% and 56.8%, respectively. However, depending on the needs of the study and the demand for diagnostic research, sensitivity and specificity may alter. Area under the ROC curve is 0.595 (95% CI: 0.586 – 0.604) (figure 4.3.3).

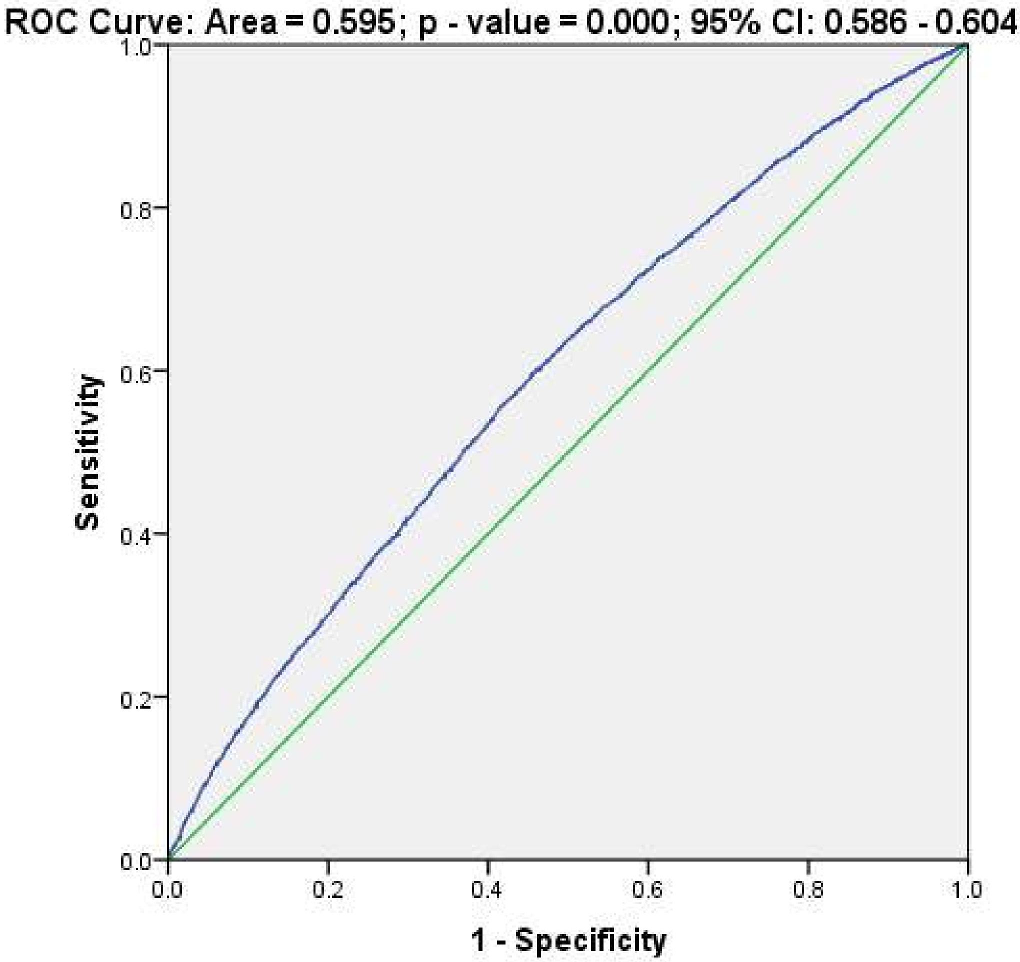


Figure. 4.3.3: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Wasting in Northeast Region of India

Table 4.3.5: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.0745775	0.970	0.064
0.0746722	0.969	0.066
0.0796757	0.958	0.086
0.0836222	0.948	0.103
0.0839956	0.947	0.105
0.0863042	0.939	0.119
0.0896364	0.928	0.136
0.0905100	0.919	0.148
0.0931058	0.909	0.162
0.0955291	0.897	0.182
0.0990091	0.879	0.205
0.1002525	0.869	0.218
0.1016006	0.858	0.237
0.1039884	0.849	0.247
0.1096652	0.799	0.308
0.1120471	0.768	0.345
0.1144431	0.759	0.355
0.1148726	0.749	0.368
0.1157364	0.739	0.385
0.1165848	0.728	0.395
0.1197381	0.709	0.418
0.1205894	0.699	0.427
0.1206042	0.697	0.428
0.1215614	0.678	0.455
0.1251690	0.659	0.475
0.1259445	0.648	0.488
0.1267993	0.627	0.510
0.1305304	0.602	0.537
0.1317457	0.594	0.545
0.1324353	0.580	0.556
0.1328988	**0.570**	**0.568**
0.1380746	0.523	0.610
0.1388582	0.512	0.621
0.1484552	0.401	0.713
0.1633862	0.278	0.818
0.1652203	0.269	0.828
0.1885530	0.139	0.925
0.1955428	0.119	0.939

4.3.4 Underweight

Table 4.3.6: - Odds Ratio of Underweight in under-5 children by socio-demographic variables in Northeast Region of India

Socio - demographic Variables	**p - value**	**OR**	**95% C.I. for OR**	
			Lower Limit	**Upper Limit**
Child Age (Month)				
< 12 *(Ref)*		1		
12 - 23	0.000	1.62	1.47	1.79
24 - 35	0.000	1.98	1.80	2.17
36 - 47	0.000	2.09	1.90	2.29
48 - 59	0.000	2.20	2.00	2.41
Child Sex				
Female *(Ref)*		1		
Male	0.000	1.12	1.06	1.19
Wealth Index				
Richest *(Ref)*		1		
Poorest	0.000	3.02	2.53	3.62
Poorer	0.000	2.37	1.99	2.81
Middle	0.000	1.94	1.64	2.30
Richer	0.012	1.26	1.05	1.50
Highest Education Level				
Higher *(Ref)*		1		
No Education	0.000	1.60	1.35	1.89
Primary	0.000	1.37	1.16	1.62
Secondary	0.038	1.18	1.01	1.37
Type of Residence				
Urban *(Ref)*		1		
Rural	0.371	1.04	0.96	1.13
Birth Order				
1 *(Ref)*		1		
2	0.867	1.01	0.94	1.08
3	0.004	1.13	1.04	1.23
4 & above	0.004	1.12	1.04	1.22
BMI				
Normal *(Ref)*		1		
Underweight	0.000	1.88	1.75	2.02
Overweight	0.000	0.66	0.60	0.74
Obese	0.000	0.56	0.42	0.74

Table 4.3.6 represents odds ratio of underweight in under-5 children by socio-demographic variables in the Northeast Region of India. In comparison to the age group below 12 months, the odds of having an underweight children were 1.6 times higher in the age group 12 to 23 month (OR: 1.62; 95% CI: 1.47 – 1.79; $p < 0.001$). In comparison to the age group below 12 months, the odds of having an underweight children were 1.9 times greater in the age group 24 to 35 month (OR: 1.98; 95% CI: 1.80 – 2.17; $p < 0.001$). In comparison to the age group below 12 months, the odds of having an underweight children were 2.1 times greater in the age group 36 to 47 month (OR: 2.09; 95% CI: 1.90 – 2.29; $p < 0.001$). In comparison to the age group below 12 months, the odds of having an underweight children were 2.2 times higher in the age group 48 to 59 month (OR: 2.20; 95% CI: 2.00 – 2.41; $p < 0.001$). Male children (OR: 1.12; 95% CI: 1.06 – 1.19; $p < 0.001$) experienced significantly higher odds of being underweight as compared to female children.

The odds of having an underweight children was three times higher in the poorest group (OR: 3.02; 95% CI: 2.53 – 3.62; $p < 0.001$) than in the richest group. In comparison to the richest group, the odds of having underweight children were 2.3 times higher in the poorer group (OR: 2.37; 95% CI: 1.99 – 2.81; $p < 0.001$). In comparison to the richest group, the odds of having underweight children were 1.9 times higher in the middle group (OR: 1.94; 95% CI: 1.64 – 2.30; $p < 0.001$). In comparison to the richest group, the odds of having underweight children were 1.2 times higher in the richer group (OR: 1.26; 95% CI: 1.05 – 1.50; $p = 0.012$).

When compared to mothers with the highest level of education, the odds of having underweight children were 1.6 times higher for mothers with no education (OR: 1.60; 95% CI: 1.35 – 1.89; $p < 0.001$). In comparison to the mother's highest educational level, the odds of having underweight children were 1.3 times higher for mothers with only a primary education (OR: 1.37; 95% CI: 1.16 – 1.62; p < 0.001)**.** In comparison to the mother's highest educational level, the odds of having underweight children were significantly higher for mothers with secondary education (OR: 1.18; 95% CI: 1.01 – 1.37; p < 0.001). In comparison to urban regions, odds of having underweight children were significantly higher in rural region (OR: 1.04; 95% CI: 0.96 – 1.13; p = 0.371). There is no significant difference in the likelihood of underweight children in rural areas as compared to urban areas.

In the second birth order (OR: 1.01; 95% CI: 0.94 – 1.08; p = 0.867) compared to the first birth order, the odds of a children having underweight was significantly higher. In comparison to the first birth order, there is no significance difference in the likelihood of underweight children in the second birth order. In comparison to the first birth order, the odds of having an underweight children were also significantly higher in the third birth order (OR: 1.13; 95% CI: 1.04 – 1.23; p < 0.004) and birth order 4 and above (OR: 1.12; 95% CI: 1.04 – 1.22; p = 0.004).

Underweight mothers (OR: 1.88; 95% CI: 1.75 – 2.02; p < 0.001) had 1.8 times higher odds of having underweight children than normal mothers. As compared to normal mothers, those with an overweight mother (OR: 0.66; 95% CI: 0.60 – 0.74; p < 0.001) had 34% lower odds of having underweight children. In comparison to normal mothers, obese mothers (OR: 0.56; 95% CI: 0.42 – 0.74; p < 0.001) had 44% lower odds of underweight children.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model are both 61.9%, as shown in Table 4.3.7. Sensitivity and specificity might change, though, depending on the objectives of the study and the need for diagnostic research. Area under the ROC Curve is 0.668 (95% CI: 0.661 – 0.675) (figure 4.3.4).

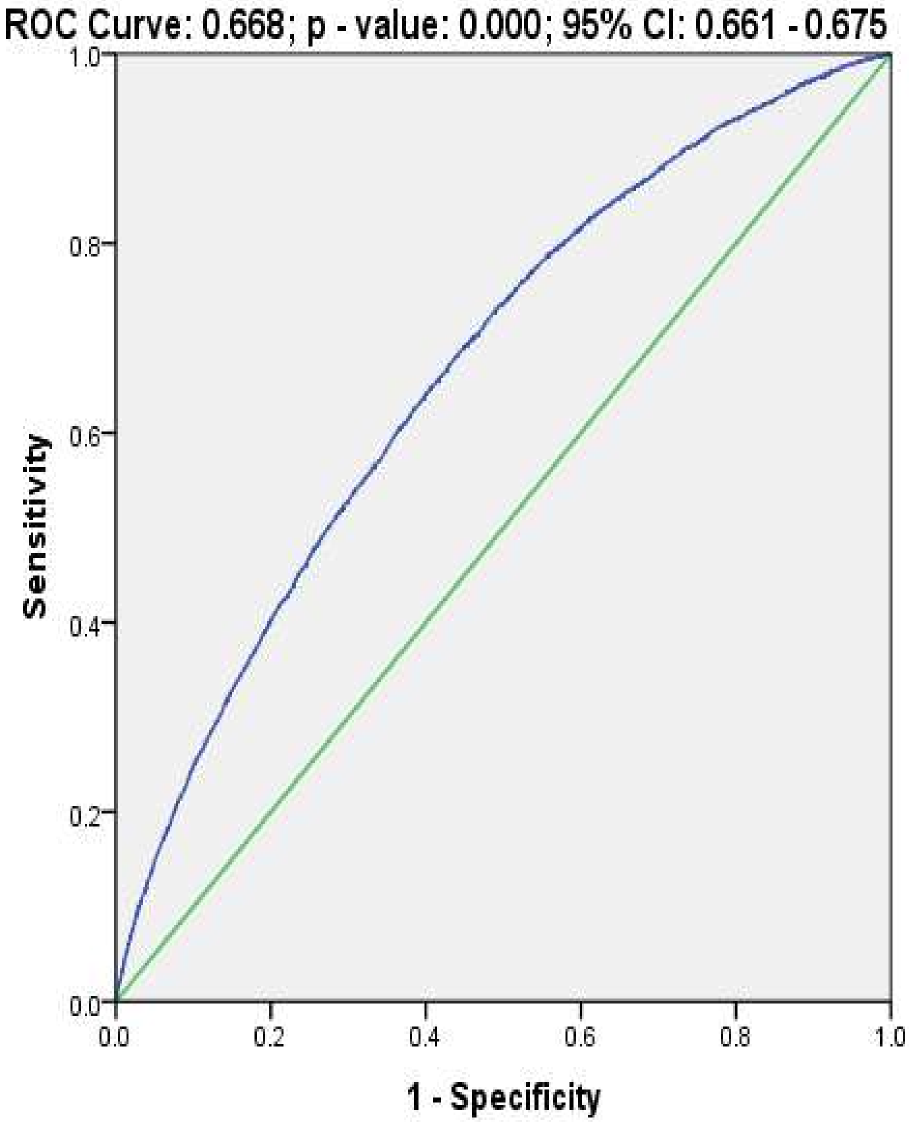


Figure. 4.3.4: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Underweight in Northeast Region of India

Table 4.3.7: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.078426	0.979	0.081
0.090456	0.969	0.112
0.098067	0.959	0.133
0.102871	0.949	0.154
0.110145	0.939	0.183
0.114642	0.929	0.205
0.119535	0.917	0.233
0.123457	0.909	0.244
0.129724	0.899	0.267
0.135207	0.879	0.297
0.138939	0.869	0.312
0.144818	0.859	0.332
0.147563	0.849	0.350
0.151404	0.838	0.368
0.156986	0.829	0.382
0.162461	0.819	0.397
0.166799	0.806	0.413
0.170165	0.799	0.424
0.173963	0.789	0.438
0.178897	0.777	0.455
0.181448	0.768	0.466
0.184515	0.759	0.476
0.188165	0.747	0.487
0.190460	0.739	0.497
0.195895	0.729	0.511
0.208575	0.668	0.572
0.211153	0.658	0.583
0.213734	0.649	0.592
0.215375	0.638	0.602
0.220581	**0.619**	**0.619**
0.246173	0.516	0.712
0.249769	0.500	0.725
0.253617	0.481	0.741
0.290982	0.363	0.826
0.295290	0.353	0.833
0.356562	0.184	0.932
0.359625	0.174	0.937

4.3.5 Estimation of Child Height

Table 4.3.8 represents the test between subjects' effects, reveals child age, birth order, respondent occupation, wealth index, sex of child and BMI is having a significant effect on Child Height except type of residence and educational level.

Table 4.3.8: Tests of Between-Subjects Effects

Dependent Variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	58.148	1	58.148	1.6	0.205
	Error	41593.284	1149.507	36.184a		
Child Age	Hypothesis	390.445	4	97.611	2.7	0.026
	Error	191400.855	5427	35.268b		
Birth Order	Hypothesis	314.97	3	104.99	2.9	0.030
	Error	191400.855	5427	35.268b		
Education Level	Hypothesis	251.655	3	83.885	2.3	0.068
	Error	191400.855	5427	35.268b		
Respondent Occupation	Hypothesis	368.756	2	184.378	5.2	0.005
	Error	191400.855	5427	35.268b		
Type of Residence	Hypothesis	5.925	1	5.925	0.1	0.682
	Error	191400.855	5427	35.268b		
Wealth Index	Hypothesis	926.532	4	231.633	6.5	< 0.001
	Error	191400.855	5427	35.268b		
BMI	Hypothesis	635.003	3	211.668	6.0	< 0.001
	Error	191400.855	5427	35.268b		
Child Sex	Hypothesis	868.13	1	868.13	24.6	< 0.001
	Error	191400.855	5427	35.268b		
FIT*	Hypothesis	47907.827	1	47907.827	1358.3	< 0.001
	Error	191400.855	5427	35.268b		
Birth Weight	Hypothesis	177.827	1	177.827	5.042	0.025
	Error	191400.855	5427	35.268b		
a .001 MS (Child Sex) + .999 MS(Error)						
b MS(Error)						

Note: - *Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 59.594 + 1.739\ Child\ Age - 0.029\ Child\ Age^2 + 0.000228\ Child\ Age^3$$

Table 4.3.9 represents factors associated with child height in northeast region. Children born in the first birth order (OR: 2.04, 95% CI: 1.27 – 3.26, $p < 0.05$) have a height which is 2 times higher than children born in the 4 & above birth order.

Children born in the second birth order (OR: 1.70, 95% CI: 1.05 – 2.75, $p < 0.05$) have a height which is 1.7 times higher than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.55, 95% CI: 0.92 – 2.62, $p = 0.102$) have a higher height than children born in the 4 & above birth order.

When compared to mothers with higher education, children of uneducated mothers (OR: 1.09, 95% CI: 0.48 - 2.47, $p = 0.840$) have higher heights. Children's height is 45% less in mothers with primary education (OR: 0.55, 95% CI: 0.25 – 1.24, $p = 0.152$) compared to mothers with higher education. Children's height is 10% less in mothers with secondary education (OR: 0.90, 95% CI: 0.45 – 1.79, $p = 0.760$) compared to mothers with higher education.

Children's height is higher in mothers with no occupation (OR: 1.25, 95% CI: 0.78 – 1.99, $p = 0.351$) compared to agricultural mothers. As compared to agricultural mothers, the height of children is 2 times more in mothers with other occupations (OR: 2.49, 95% CI: 1.36 – 4.55, $p < 0.05$). As compared to rural region, the height of children is higher in urban region (OR: 1.10, 95% CI: 0.71 – 1.69, $p = 0.682$).

Children in the poorest group (OR: 0.21, 95% CI: 0.09 – 0.47, $p < 0.05$) have 79% less height than children in the richest group. Children in the poorer group (OR: 0.28, 95% CI: 0.13 – 0.61, $p < 0.05$) have 72% less height than children in the richest group. Children in the middle group (OR: 0.46, 95% CI: 0.22 – 0.97, $p < 0.05$) have 54% less height than children in the richest group. Children in the richer group (OR: 0.86, 95% CI: 0.41 – 1.80, $p = 0.694$) have 14% less height than children in the richest group.

The height of children with normal BMI (OR: 0.25, 95% CI: 0.08 – 0.81, $p < 0.05$) is 75% less than that of those with obese BMI. The height of children with underweight BMI (OR: 0.16, 95% CI: 0.04 – 0.54, $p < 0.05$) is 84% lesser than that of children with obese BMI. The height of children with overweight BMI (OR: 0.51, 95% CI: 0.15 – 1.75, p = 0.283) is 49% lesser than that of children with obese BMI. As compared to female children, height of male children (OR: 2.23, 95% CI: 1.62 – 3.06, p < 0.05) is 2.2 times higher.

Table 4.3.9: Factors Associated with Child Height in Northeast Region

Dependent Variable: Child Height					
Parameter	B	p - value	95% CI		OR (95% CI)
			LL	UL	
Birth Order					
1	0.712	0.003	0.241	1.182	2.04 (1.27, 3.26)
2	0.531	0.030	0.05	1.013	1.70 (1.05, 2.75)
3	0.438	0.102	-0.086	0.963	1.55 (0.92, 2.62)
4 & above *(Ref.)*	0				
Education Level					
No Education	0.085	0.840	-0.737	0.906	1.09 (0.48, 2.47)
Primary	-0.589	0.152	-1.394	0.217	0.55 (0.25, 1.24)
Secondary	-0.107	0.760	-0.797	0.582	0.90 (0.45, 1.79)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	0.222	0.351	-0.245	0.69	1.25 (0.78, 1.99)
Other	0.911	0.003	0.305	1.516	2.49 (1.36, 4.55)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	0.091	0.682	-0.342	0.523	1.10 (0.71, 1.69)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-1.582	0.000	-2.417	-0.746	0.21 (0.09, 0.47)
Poorer	-1.261	0.001	-2.027	-0.496	0.28 (0.13, 0.61)
Middle	-0.777	0.041	-1.524	-0.03	0.46 (0.22, 0.97)
Richer	-0.148	0.694	-0.886	0.59	0.86 (0.41, 1.80)
Richest *(Ref.)*	0				
BMI					
Normal	-1.39	0.021	-2.571	-0.209	0.25 (0.08, 0.81)
Underweight	-1.861	0.003	-3.109	-0.613	0.16 (0.04, 0.54)
Overweight	-0.678	0.283	-1.916	0.56	0.51 (0.15, 1.75)
Obese *(Ref.)*	0				
Child Sex					
Male	0.800	0.000	0.484	1.117	2.23 (1.62, 3.06)
Female *(Ref.)*	0				
FIT	1.029	0.000	0.974	1.083	2.80 (2.65, 2.95)
Birth Weight	0.729	0.025	0.092	1.365	2.07 (1.10, 3.92)

**Note: - ***Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 59.594 + 1.739\ Child\ Age - 0.029\ Child\ Age^2 + 0.000228\ Child\ Age^3$$

Table 4.3.10 represents the descriptive statistics of child height by birth order. The mean height of a child in first and second birth order is around 85.1 cm and 84.9 cm, respectively. The mean height of a child in third and 4 & above birth order is around 84.8 cm and 84.4 cm, respectively.

Table 4.3.10: - Descriptive of Child Height by Birth Order

Dependent Variable: Child Height				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	85.16	0.23	84.71	85.61
2	84.98	0.24	84.52	85.44
3	84.89	0.26	84.37	85.40
4 & above	84.45	0.25	83.96	84.94

Table 4.3.11 represents a pairwise comparison of child height by birth order. Mean difference of child height between first and second birth order (M D = 0.180, 95% CI: -0.23 to 0.59, p = 0.385), between first and third birth order (M D = 0.274, 95% CI: -0.21 to 0.75, p = 0.262) is statistically insignificant. But mean difference of child height between first and 4 & above birth order (M D = 0.712, 95% CI: 0.24 to 1.18, $p < 0.05$) is statistically significant. Mean difference of child height between second and third birth order (M D = 0.093, 95% CI: -0.40 to 0.59, p = 0.711) is statistically insignificant. But, mean difference of child height between second and 4 & above birth order (M D = 0.531, 95% CI: 0.05 to 1.01, $p < 0.05$) is statistically significant. Mean difference of child height between third and 4 & above birth order (M D = 0.438, 95% CI: -0.09 to 0.96, p-value = 0.102).

Table 4.3.11: - Pairwise Comparisons of Child Height by Birth Order

Dependent Variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
1	2	0.180	0.21	0.385	-0.23	0.59
	3	0.274	0.24	0.262	-0.21	0.75
	4 & above	0.712*	0.24	0.003	0.24	1.18
2	3	0.093	0.25	0.711	-0.40	0.59
	4 & above	0.531*	0.25	0.030	0.05	1.01
3	4 & above	0.438	0.27	0.102	-0.09	0.96
*Mean difference is significant at the 0.05 level.						

Table 4.3.12 represents the descriptive statistics of child height by educational level. The mean height of a child for mothers with no education is around 85.1 cm. For mothers with primary education, average height of the child is around 84.4 cm. For mothers with secondary education, average height of the child is around 84.9 cm. Similarly, for mothers with higher education, the average child's height is around 85 cm.

Table 4.3.12: - Descriptive of Child Height by Education Level

Dependent Variable: Child Height				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	85.11	0.27	84.57	85.64
Primary	84.43	0.26	83.92	84.95
Secondary	84.91	0.21	84.51	85.32
Higher	85.02	0.36	84.32	85.73

Table 4.3.13 represents a pairwise comparison of child height by educational level. Mean difference of child height between mothers with no education and primary education (M D = 0.673, 95% CI: 0.15 to 1.20, $p < 0.05$) is statistically significant. But, Mean difference of child height between mothers with no education and secondary education (M D = 0.192, 95% CI: -0.29 to 0.67, $p = 0.430$) and mothers with no education and higher education (M D = 0.085, 95% CI: -0.74 to 0.91, $p = 0.840$) is statistically insignificant. Mean difference of child height between

mothers with primary and secondary education (M D = -0.481, 95% CI: -0.94 to -0.02, p < 0.05) is statistically significant. Mean difference of child height between mothers with primary and higher education (M D = -0.589, 95% CI: -1.39 to 0.22, p = 0.152) is statistically insignificant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.107, 95% CI: -0.80 to 0.58, p = 0.760) is statistically insignificant.

Table 4.3.13: - Pairwise Comparisons of Child Height by Highest Education Level

Dependent Variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
No education	Primary	0.673*	0.27	0.012	0.15	1.20
	Secondary	0.192	0.24	0.430	-0.29	0.67
	Higher	0.085	0.42	0.840	-0.74	0.91
Primary	Secondary	-0.481*	0.23	0.040	-0.94	-0.02
	Higher	-0.589	0.41	0.152	-1.39	0.22
Secondary	Higher	-0.107	0.35	0.760	-0.80	0.58
*Mean difference is significant at the 0.05 level.						

Table 4.3.14 represents the descriptive statistics of child height by respondent occupation. Mean height of the child for mothers with no occupation is around 84.7 cm. But, for mothers with other occupation and agricultural mothers, average height of the child is around 85.4 cm and 84.5 cm, respectively.

Table 4.3.14: - Descriptive of Child Height by Respondent Occupation

Dependent Variable: Child Height				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	84.713	0.194	84.333	85.094
Other	85.402	0.258	84.896	85.908
Agriculture	84.491	0.281	83.941	85.042

Table 4.3.15 represents a pairwise comparison of child height by respondent occupation. Mean difference of child height between mothers with no occupation and mothers with other occupation (M D = -0.688, 95% CI: -1.15 to -0.23, p < 0.05) is

statistically significant. Similarly, mean difference of child height between mothers with no occupation and mothers doing agriculture (M D = 0.222, 95% CI: 0.25 to 0.69, p = 0.351) is statistically insignificant. Mean difference of child height between mothers with other occupation and mothers doing agriculture (M D = 0.911, 95% CI: 0.31 to 1.52, p < 0.05) is statistically significant.

Table 4.3.15: - Pairwise Comparisons of Child Height by Respondent Occupation

Dependent Variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
No Occupation	Other	-0.688*	0.24	0.004	-1.15	-0.23
	Agriculture	0.222	0.24	0.351	-0.25	0.69
Other	Agriculture	0.911*	0.31	0.003	0.31	1.52
*Mean difference is significant at the 0.05 level.						

Table 4.3.16 represents the descriptive statistics of Child Height by Type of Residence. Mean height of child urban as well as rural regions is around 84.9 cm and 84.8 cm, respectively.

Table 4.3.16: - Descriptive Statistics of Child Height by Type of Residence

Dependent Variable: Child Height				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	84.914	0.244	84.435	85.393
Rural	84.823	0.202	84.428	85.219

Table 4.3.17 represents a pairwise comparison of child height by Type of Residence. Mean difference of child height between urban region and rural region (M D = 0.091, 95% CI: -0.342 to 0.523, p-value = 0.682), is statistically insignificant.

Table 4.3.17: - Pairwise Comparisons of Child Height by Type of Residence

Dependent Variable: Child Height						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Urban	Rural	0.091	0.221	0.682	-0.342	0.523

Table 4.3.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 84 cm. In the poorer and middle groups, children's average height is around 84.4 cm and 84 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 85.5 cm and 85.6 cm, respectively.

Table 4.3.18: - Descriptive of Child Height by Wealth Index

Dependent Variable: Child Height				
Wealth index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	84.04	0.28	83.49	84.60
Poorer	84.36	0.25	83.87	84.85
Middle	84.85	0.26	84.35	85.35
Richer	85.47	0.27	84.95	86.00
Richest	85.62	0.35	84.94	86.30

Table 4.3.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and middle group (M D = -0.804, 95% CI: -1.33 to -0.28, $p < 0.05$), between poorest group and richer group (M D = -1.433, 95% CI: -2.06 to -0.81, $p < 0.05$), and between poorest group and richest group (M D = -1.582, 95% CI: -2.42 to –0.75, $p < 0.05$) is statistically significant. Mean difference of child height between poorer group and middle group (M D = -0.484, 95% CI: -0.92 to –0.05, $p < 0.05$), between poorer group and richer group (M D = - 1.113, 95% CI: -1.65 to – 0.58, $p < 0.05$), and between poorer group and richest group (M D = -1.261, 95% CI: -2.03 to –0.50, $p < 0.05$) is statistically significant. Mean difference of child height between middle group and richer group (M D = -0.629, 95% CI: -1.16 to –0.10, $p < 0.05$), between middle group and the richest group (M D = - 0.777, 95% CI: -1.52 to – 0.03, $p < 0.05$) is statistically significant.

Table 4.3.19: - Pairwise Comparisons of Child Height by Wealth Index

Dependent Variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Poorest	Poorer	-0.320	0.24	0.180	-0.79	0.15
	Middle	-.804*	0.27	0.003	-1.33	-0.28
	Richer	-1.433*	0.32	0.000	-2.06	-0.81
	Richest	-1.582*	0.43	0.000	-2.42	-0.75
Poorer	Middle	-0.484*	0.22	0.030	-0.92	-0.05
	Richer	-1.113*	0.27	0.000	-1.65	-0.58
	Richest	-1.261*	0.39	0.001	-2.03	-0.50
Middle	Richer	-0.629*	0.27	0.020	-1.16	-0.10
	Richest	-0.777*	0.38	0.041	-1.52	-0.03
Richer	Richest	-0.148	0.38	0.694	-0.89	0.59
* The mean difference is significant at the 0.05 level.						

Table 4.3.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 85 cm. Similarly, children's average height in females is around 84.4 cm.

Table 4.3.20: - Descriptive Statistics of Child Height by Child Sex

Dependent Variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	85.27	0.21	84.85	85.68
Female	84.47	0.21	84.06	84.88

Table 4.3.21 represents a pairwise comparison of child height by Child Sex. Mean difference of child height between in male children and female children (M D = 0.800, 95% CI: 0.48 to 1.12, $p < 0.05$) is statistically significant.

Table 4.3.21: - Pairwise Comparisons of Child Height by Child Sex

Dependent Variable: Child Height						
Child Sex	Child Sex	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Male	Female	0.800*	0.16	0.000	0.48	1.12
* The mean difference is significant at the 0.05 level.						

Table 4.3.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as in underweight BMI is around 84.5 cm and 83.9 cm. The average height of a child with an overweight BMI is around 85 cm. Similarly, children's average height in obese BMI is around 85.8 cm.

Table 4.3.22: - Descriptive Statistics of Child Height by BMI

Dependent Variable: Child height				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	84.46	0.15	84.18	84.75
Underweight	83.99	0.25	83.50	84.48
Overweight	85.17	0.25	84.69	85.66
Obese	85.85	0.60	84.68	87.02

Table 4.3.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.471, 95% CI: 0.005 to 0.937, $p < 0.05$), between normal BMI and overweight BMI (M D = -0.712, 95% CI: -1.21 to -0.213, $p < 0.05$), and between normal BMI and obese BMI (M D = -1.390, 95% CI: -2.571 to -0.209, $p < 0.05$) is statistically significant. Mean difference of child height between underweight BMI and overweight BMI (M D = -1.183, 95% CI: -1.82 to –0.56, $p < 0.05$) and between underweight BMI and obese BMI (M D = -1.861 95% CI: -3.109 to -0.613, $p < 0.05$) is statistically significant. Mean difference of child height between overweight BMI and underweight BMI (M D = -1.183 95% CI: 0.546 to 1.820, p-value < 0.05) is statistically significant.

Table 4.3.23: - Pairwise Comparisons of Child Height by BMI

Dependent Variable: Child height						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Normal	Underweight	0.471*	0.238	0.048	0.005	0.937
	Overweight	-0.712*	0.254	0.005	-1.21	-0.213
	Obese	-1.390*	0.602	0.021	-2.571	-0.209
Underweight	Overweight	-1.183*	0.325	0.000	-1.82	-0.546
	Obese	-1.861*	0.637	0.003	-3.109	-0.613
Overweight	Underweight	1.183*	0.325	0.000	0.546	1.820
	Obese	-0.678	0.631	0.283	-1.916	0.560
*Mean difference is significant at the 0.05 level.						

4.3.6 Estimation of Child Weight

Table 4.3.24 represents the test between subjects' effects, revealing child age, educational level, wealth index, sex of child and BMI have a significant effect on Child Weight except respondent occupation, birth order, and place of residence.

Table 4.3.24: Tests of Between-Subjects Effects

Dependent Variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p-value
Intercept	Hypothesis	0.862	1	0.862	0.229	0.639
	Error	57.849	15.395	3.758a		
Child Age	Hypothesis	346.402	4	86.6	30.822	0.000
	Error	15343.9	5461	2.810b		
Birth Order	Hypothesis	17.742	3	5.914	2.105	0.097
	Error	15343.9	5461	2.810b		
Educational Level	Hypothesis	29.564	3	9.855	3.507	0.015
	Error	15343.9	5461	2.810b		
Respondent Occupation	Hypothesis	7.498	2	3.749	1.334	0.263
	Error	15343.9	5461	2.810b		
Place of Residence	Hypothesis	0.436	1	0.436	0.155	0.694
	Error	15343.9	5461	2.810b		
Wealth Index	Hypothesis	155.865	4	38.966	13.868	0.000
	Error	15343.9	5461	2.810b		
BMI	Hypothesis	305.972	3	101.991	36.299	0.000
	Error	15343.9	5461	2.810b		
Child Sex	Hypothesis	295.595	1	295.595	105.204	0.000
	Error	15343.9	5461	2.810b		
FIT	Hypothesis	2511.912	1	2511.912	894.007	0.000
	Error	15343.9	5461	2.810b		
Birth Weight	Hypothesis	66.392	1	66.392	23.630	0.000
	Error	15343.9	5461	2.810b		
a .003 MS (Child Sex) + .997 MS(Error)						
b MS(Error)						

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:
$Child\ Weight = 3.630\ Child\ Age^{0.336}$

Table 4.3.25 represents factors associated with child weight in the northeast region. When compared to children between the ages of 48 and 59 months, children under the age of 12 months (OR: 0.62, 95% CI: 0.38 – 1.00, p = 0.051) weigh 38% less. The weight of children between the ages of 12 and 23 months (OR: 0.44, 95% CI: 0.32 – 0.60, p < 0.05) is 56 % less than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.47, 95% CI: 0.38 – 0.58, p < 0.05) weigh 53% less than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.69, 95% CI: 0.59 – 0.81, p < 0.05) weigh 31% less.

Children born in the first birth order (OR: 1.12, 95% CI: 0.99 – 1.28, p = 0.083) weigh more than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.10, 95% CI: 0.96 – 1.26, p = 0.151) also weigh more than children born in the 4 & above birth order. Children born in the third birth order (OR: 0.97, 95% CI: 0.84 – 1.13, p = 0.694) weigh 3% less than children born in the 4 & above birth order.

Children's weight is 31% less in mothers with no education (OR: 0.69, 95% CI: 0.55 – 0.87, p < 0.05) compared to mothers with higher education. Children's weight is 29% less in mothers with primary education (OR: 0.71, 95% CI: 0.57 – 0.89, p < 0.05) compared to mothers with higher education. Children's weight is 23% less in mothers with secondary education (OR: 0.77, 95% CI: 0.64 – 0.94, p < 0.05) compared to mothers with higher education.

Children's weight is 10% less in mothers with no occupation (OR: 0.90, 95% CI: 0.79 – 1.02, p = 0.102) compared to agricultural mothers. As compared to agricultural mothers, the weight of children is 9% less in mothers with other occupations (OR: 0.91, 95% CI: 0.77 – 1.08, p = 0.289). As compared to rural regions, the weight of children is 2% less in urban regions (OR: 0.98, 95% CI: 0.89 – 1.10, p = 0.694).

Children in the poorest group (OR: 0.47, 95% CI: 0.37 – 0.59, $p < 0.05$) have 53% less weight than children in the richest group. Children in the poorer group (OR: 0.50, 95% CI: 0.41 – 0.62, $p < 0.05$) have 50% less weight than children in the richest group. Children in the middle group (OR: 0.64, 95% CI: 0.52 – 0.79, $p < 0.05$) have 36% less weight than children in the richest group. Children in the richer group (OR: 0.73, 95% CI: 0.59 – 0.90, $p < 0.05$) have 27% less weight than children in the richest group.

The weight of children with normal women (OR: 0.55, 95% CI: 0.39 – 0.76, $p < 0.05$) is 45% less than that of those with obese women. The weight of children with underweight women (OR: 0.34, 95% CI: 0.24 – 0.49, $p < 0.05$) is around 66% less than that of children with obese women. The weight of children with overweight women (OR: 0.84, 95% CI: 0.59 – 1.19, p = 0.320) is 16% less than that of children with obese women. As compared to female children, the weight of male children (OR: 1.59, 95% CI: 1.46 – 1.74, $p < 0.05$) is around 2 times higher.

Table 4.3.25: Factors Associated with Child Weight in the Northeast Region

Dependent Variable: Child Weight					
Parameter	B	p-value	95% CI		OR (95% CI)
			LL	UL	
Child Age (Months)					
< 12	-0.479	0.051	-0.959	0.002	0.62 (0.38, 1.00)
12 - 23	-0.823	0.000	-1.131	-0.515	0.44 (0.32, 0.60)
24 - 35	-0.753	0.000	-0.967	-0.538	0.47 (0.38, 0.58)
36 - 47	-0.369	0.000	-0.525	-0.212	0.69 (0.59, 0.81)
48 - 59 *(Ref.)*	0				
Birth Order					
1	0.117	0.083	-0.015	0.249	1.12 (0.99, 1.28)
2	0.099	0.151	-0.036	0.234	1.10 (0.96, 1.26)
3	-0.03	0.694	-0.178	0.118	0.97 (0.84, 1.13)
4 & above *(Ref.)*	0				
Education Level					
No Education	-0.369	0.002	-0.6	-0.138	0.69 (0.55, 0.87)
Primary	-0.343	0.003	-0.569	-0.116	0.71 (0.57, 0.89)
Secondary	-0.259	0.009	-0.453	-0.065	0.77 (0.64, 0.94)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	-0.11	0.102	-0.241	0.022	0.90 (0.79, 1.02)
Others	-0.092	0.289	-0.263	0.078	0.91 (0.77, 1.08)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	-0.024	0.694	-0.146	0.097	0.98 (0.86, 1.10)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-0.762	0.000	-0.996	-0.527	0.47 (0.37, 0.59)
Poorer	-0.687	0.000	-0.902	-0.472	0.50 (0.41, 0.62)
Middle	-0.443	0.000	-0.653	-0.234	0.64 (0.52, 0.79)
Richer	-0.318	0.003	-0.525	-0.11	0.73 (0.59, 0.90)
Richest *(Ref.)*	0				
BMI					
Normal	-0.604	0.00	-0.939	-0.269	0.55 (0.39, 0.76)
Underweight	-1.076	0.00	-1.429	-0.723	0.34 (0.24, 0.49)
Overweight	-0.178	0.32	-0.529	0.173	0.84 (0.59, 1.19)
Obese *(Ref.)*	0				
Child Sex					
Male	0.466	0.000	0.377	0.555	1.59 (1.46, 1.74)
Female *(Ref.)*	0				
FIT*	0.979	0.000	0.915	1.044	2.66 (2.5, 2.84)
Birth Weight	0.442	0.000	0.264	0.62	1.56 (1.30, 1.86)

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.630\ Child\ Age^{0.336}$$

Table 4.3.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in the less than 12-month age group is around 11.3 kg. The mean weight of a child in the 12 - 23 months and 24 - 35 months age group is around 10.9 kg and 11 kg, respectively. The mean weight of a child in the 36 - 47 months age group is around 11.3 kg. The mean weight of a child in the 48 - 59 months age group is around 11.7 kg.

Table 4.3.26: Descriptive Statistics of Child Weight by Child Age

Dependent Variable: Child Weight				
Child Age	Mean	Std. Error	95% CI	
			LL	UL
< 12	11.286	0.154	10.984	11.589
12 - 23	10.942	0.084	10.778	11.107
24 - 35	11.013	0.073	10.869	11.157
36 - 47	11.397	0.093	11.215	11.579
48 - 59	11.765	0.12	11.53	12.001

Table 4.3.27 represents a pairwise comparison of child weight by child age. A mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.344, 95% CI: 0.109 to 0.579, $p < 0.05$) is statistically significant. A mean difference of child weight between 12 - 23 months and 36 - 47 months age group (M D = - 0.454, 95% CI: -0.699 to - 0.210, $p < 0.05$), between 12 - 23 months and 48 - 59 months age group (M D = - 0.823, 95% CI: -1.131 to - 0.515, $p < 0.05$) is statistically significant. A mean difference in child weight between the 24 - 35 months and 36 - 47 months age group (M D = -0.384, 95% CI: -0.549 to - 0.219, $p < 0.05$), and between 24 - 35 months and 48 - 59 months age group (M D = -0.753, 95% CI: -0.967 to - 0.538, $p < 0.05$) is statistically significant. A mean difference in child weight between the 36 - 47 months and 48 -59 months age group (M D = -0.369, 95% CI: -0.525 to - 0.212, $p < 0.05$) is statistically significant.

Table 4.3.27: Pairwise Comparisons of Child Weight by Child Age

Dependent Variable: Child Weight						
Child Age	Child Age	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
< 12	12 - 23	0.344*	0.12	0.004	0.109	0.579
	24 - 35	0.274	0.168	0.103	-0.056	0.603
	36 - 47	-0.110	0.209	0.598	-0.521	0.300
	48 - 59	-0.479	0.245	0.051	-0.959	0.002
12 - 23	24 - 35	-0.070	0.093	0.447	-0.252	0.111
	36 - 47	-0.454*	0.125	0.000	-0.699	-0.210
	48 - 59	-0.823*	0.157	0.000	-1.131	-0.515
24 - 35	36 - 47	-0.384*	0.084	0.000	-0.549	-0.219
	48 - 59	-0.753*	0.11	0.000	-0.967	-0.538
36 - 47	48 - 59	-0.369*	0.08	0.000	-0.525	-0.212
*Mean difference is significant at the .05 level.						

Table 4.3.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in the first as well as second birth order is around 11.3 kg. For the third birth order as well as the 4 & above birth order, the mean weight of a child is around 11.2 kg.

Table 4.3.28: Descriptive Statistics of Child Weight by Birth Order

Dependent Variable: Child Weight				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	11.351	0.065	11.223	11.479
2	11.333	0.067	11.203	11.464
3	11.205	0.074	11.059	11.35
4 & above	11.234	0.071	11.096	11.373

Table 4.3.29 represents a pairwise comparison of child weight by birth order. A mean difference of child weight between first and second birth order (M D = 0.018, 95% CI: -0.096 to - 0.132, $p = 0.758$), and between first and 4 & above birth order (M D = 0.117, 95% CI: -0.015 to 0.249, $p = 0.083$) is statistically insignificant. However, the Mean difference in child weight between the first and third birth order (M D = 0.147, 95% CI: -0.012 to - 0.282, $p < 0.05$) is statistically significant. The mean weight difference in children between second and third birth orders (M D = 0.129,

95% CI: -0.011 to 0.268, p = 0.070) as well as between second and 4 & above birth orders (M D = 0.099, 95% CI: -0.036 to 0.234, p = 0.151) is statistically insignificant. The mean weight difference in children between third and 4 & above birth orders (M D = -0.030, 95% CI: -0.176 to 0.118, p = 0.694).

Table 4.3.29: Pairwise Comparisons of Child Weight by Birth Order

Dependent Variable: Child Weight						
Birth Order	Birth Order	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
1	2	0.018	0.058	0.758	-0.096	0.132
	3	0.147*	0.069	0.033	0.012	0.282
	4 & above	0.117	0.068	0.083	-0.015	0.249
2	3	0.129	0.071	0.070	-0.011	0.268
	4 & above	0.099	0.069	0.151	-0.036	0.234
3	4 & above	-0.030	0.075	0.694	-0.178	0.118
* Mean difference is significant at the .05 level.						

Table 4.3.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 11.2 kg. For mothers with primary education, the average weight of the child is around 11.2 kg. For mothers with secondary education, the average weight of the child is around 11.3 kg. Similarly, for mothers with higher education, the average child's weight is around 11.5 kg.

Table 4.3.30: Descriptive Statistics of Child Weight by Educational Level

Dependent Variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	11.155	0.076	11.005	11.305
Primary	11.181	0.075	11.035	11.327
Secondary	11.264	0.059	11.149	11.379
Higher	11.524	0.101	11.325	11.722

Table 4.3.31 represents a pairwise comparison of child weight by educational level. A mean difference in child weight between mothers with no education and higher education (M D = 0.369, 95% CI: -0.600 to -0.138, p < 0.05) is statistically

significant. A mean difference in child weight between mothers with primary and higher education (M D = 0.343, 95% CI: -0.569 to -0.116, p < 0.05) is statistically significant. A mean difference in child weight between mothers with secondary and higher education (M D = -0.259, 95% CI: -0.453 to -0.065, p < 0.05) is statistically significant.

Table 4.3.31: Pairwise Comparisons of Child Weight by Educational Level

Dependent Variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
No education	Primary	-0.026	0.075	0.73	-0.174	0.122
	Secondary	-0.109	0.068	0.11	-0.243	0.025
	Higher	-0.369*	0.118	0.002	-0.600	-0.138
Primary	Secondary	-0.083	0.066	0.206	-0.212	0.046
	Higher	-0.343*	0.116	0.003	-0.569	-0.116
Secondary	Higher	-0.259*	0.099	0.009	-0.453	-0.065
*Mean difference is significant at the 0.05 level.						

Table 4.3.32 represents the descriptive statistics of child weight by respondent occupation. The mean weight of the child for mothers with no occupation is around 11.2 kg. For mothers with other occupations and agricultural mothers, the average weight of the child is around 11.2 kg and 11.3 kg, respectively.

Table 4.3.32: Descriptive Statistics of Child Weight by Respondent Occupation

Dependent Variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	11.238	0.055	11.131	11.346
Other	11.256	0.073	11.113	11.399
Agriculture	11.348	0.079	11.193	11.503

Table 4.3.33 represents a pairwise comparison of child weight by respondent occupation. The mean difference in child weight between mothers with no occupation and other occupation (M D = -0.017, 95% CI: -0.148 to 0.113, p = 0.794), and between mothers with no occupation and agricultural mothers (M D = -0.110, 95% CI: -0.241 to -0.022, p = 0.102) is statistically insignificant. Similarly, the mean

difference in child weight between mothers' other occupations and agricultural mothers (M D = -0.092, 95% CI: -0.263 to -0.078, p = 0.289) is statistically insignificant.

Table 4.3.33: Pairwise Comparisons of Child Weight by Respondent Occupation

Dependent Variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
No Occupation	Other	-0.017	0.066	0.794	-0.148	0.113
	Agriculture	-0.110	0.067	0.102	-0.241	0.022
Other	Agriculture	-0.092	0.087	0.289	-0.263	0.078

Table 4.3.34 represents the descriptive statistics of child weight by type of residence. The mean weight of a child in urban is around 11.3 kg and the mean weight of a child in rural is around 11.3 kg.

Table 4.3.34: Descriptive Statistics of Child Weight by Type of Residence

Dependent Variable: Child Weight				
Type of residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	11.269	0.069	11.134	11.404
Rural	11.293	0.057	11.181	11.405

Table 4.3.35 represents a pairwise comparison of child weight by type of residence. The mean difference in child weight between urban and rural regions (M D = -0.294, 95% CI: 0.146 to 0.097, p = 0.694) is statistically insignificant.

Table 4.3.35: Pairwise Comparisons of Child Weight by Type of Residence

Dependent Variable: Child Weight						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Urban	Rural	-0.024	0.062	0.694	-0.146	0.097

Table 4.3.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.9 kg. In the poorer groups, children's average weight is around 11 kg. In the middle groups, children's average weight is around 11.2 kg. Similarly, in richer as well as richest groups, the average weight of children is around 11.4 kg and 11.7 kg, respectively.

Table 4.3.36: Descriptive Statistics of Child Weight by Wealth Index

Dependent Variable: Child Weight				
Wealth index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.961	0.080	10.805	11.117
Poorer	11.036	0.070	10.898	11.174
Middle	11.279	0.072	11.138	11.420
Richer	11.405	0.076	11.257	11.553
Richest	11.723	0.098	11.531	11.915

Table 4.3.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest group and middle group (M D = - 0.318, 95% CI: -0.467 to - 0.170, $p < 0.05$), between poorest group and richer group (M D = - 0.444, 95% CI: -0.620 to - 0.268, $p < 0.05$), and between poorest group and richest group (M D = - 0.762, 95% CI: -0.996 to - 0.527, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and middle group (M D = - 0.243, 95% CI: -0.366 to – 0.120, $p < 0.05$), between poorer group and richer group (M D = - 0.369, 95% CI: -0.520 to – 0.218, $p < 0.05$), and between poorer group and richest group (M D = - 0.687, 95% CI: -0.902 to – 0.472, $p < 0.05$) is statistically significantly. The mean difference in child weight between the middle and richest group (M D = - 0.443, 95% CI: -0.653 to – 0.234, $p < 0.05$) is statistically significant. The mean difference in child weight between the richer and richest groups (M D = - 0.318, 95% CI: -0.525 to – 0.110, $p < 0.05$) is statistically significant.

Table 4.3.37: Pairwise Comparisons of Child Weight by Wealth Index

Dependent Variable: Child Weight						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Poorest	Poorer	-0.075	0.067	0.261	-0.207	0.056
	Middle	-0.318*	0.076	0.000	-0.467	-0.170
	Richer	-0.444*	0.090	0.000	-0.62	-0.268
	Richest	-0.762*	0.120	0.000	-0.996	-0.527
Poorer	Middle	-0.243*	0.063	0.000	-0.366	-0.120
	Richer	-0.369*	0.077	0.000	-0.520	-0.218
	Richest	-0.687*	0.110	0.000	-0.902	-0.472
Middle	Richer	-0.126	0.076	0.098	-0.275	0.023
	Richest	-0.443*	0.107	0.000	-0.653	-0.234
Richer	Richest	-0.318*	0.106	0.003	-0.525	-0.110
*Mean difference is significant at the 0.05 level.						

Table 4.3.38 represents the descriptive statistics of child weight by BMI. The average weight of a child with a normal woman is around 11.1 kg. The average weight of a child in an underweight woman is around 10.6 kg. The average weight of a child in an overweight woman is around 11.5 kg. Similarly, children's average weight in obese women is around 11.7 kg.

Table 4.3.38: Descriptive Statistics of Child Weight by BMI

Dependent Variable: Child Weight				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	11.141	0.041	11.061	11.221
Underweight	10.669	0.071	10.531	10.808
Overweight	11.568	0.070	11.43	11.705
Obese	11.745	0.169	11.414	12.076

Table 4.3.39 represents a pairwise comparison of child weight by BMI. The mean difference in child weight between a normal woman and an underweight woman (M D = 0.472, 95% CI: 0.341 to 0.609, $p < 0.05$), between a normal woman and overweight woman (M D = - 0.426, 95% CI: - 0.567 to - 0.286, $p < 0.05$) is statistically significant. Also, the mean difference in child weight between normal women and obese women (M D = - 0.604, 95% CI: -0.939 to - 0.269, $p < 0.05$) is statistically significant. Mean difference in child weight between underweight women

and overweight women (M D = - 0.898, 95% CI: -1.077 to - 0.719, $p < 0.05$) and between underweight woman and obese woman (M D = - 1.076, 95% CI: -1.429 to - 0.723, $p < 0.05$) is statistically significant.

Table 4.3.39: Pairwise Comparisons of Child Weight by BMI

Dependent Variable: Child Weight						
BMI	BMI	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Normal	Underweight	0.472*	0.067	0.000	0.341	0.602
	Overweight	-0.426*	0.072	0.000	-0.567	-0.286
	Obese	-0.604*	0.171	0.000	-0.939	-0.269
Underweight	Overweight	-0.898*	0.091	0.000	-1.077	-0.719
	Obese	-1.076*	0.18	0.000	-1.429	-0.723
Overweight	Obese	-0.178	0.179	0.321	-0.529	0.173
* Mean difference is significant at the 0.05 level.						

Table 4.3.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 11.5 kg. Similarly, children's average weight in females is around 11 kg.

Table 4.3.40: Descriptive Statistics of Child Weight by Child Sex

Dependent Variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	11.514	0.060	11.397	11.631
Female	11.048	0.059	10.932	11.165

Table 4.3.41 represents a pairwise comparison of child weight by Child Sex. The mean difference in child weight between male children and female children (M D = 0.466, 95% CI: 0.377 to 0.555, $p < 0.05$) is statistically significant.

Table 4.3.41: Pairwise Comparisons of Child Weight by Child Sex

Dependent Variable: Child Weight						
Sex of child	Sex of child	Mean Difference	Std. Error	p-value	95% CI	
					LL	UL
Male	Female	0.466*	0.045	0.000	0.377	0.555
*Mean difference is significant at the 0.05 level.						

4.3.7 Growth Nomograms

Table 4.3.42: Birth-weight categories of under-5 Children by their socio-demographic characteristics

Socio-demographic Variables		Birthweight (gm)								
		< 2000		2000 - 2499		2500 - 2999		3000+		Total
		n_1	%	n_2	%	n_3	%	n_4	%	n
Child Age	< 12	30	1.7	168	9.6	495	28.3	1056	60.4	1749
	12 - 23	34	2.2	137	8.9	440	28.5	929	60.3	1540
	24 - 35	37	2.2	146	8.6	489	28.9	1022	60.3	1694
	36 - 47	33	1.9	132	7.5	452	25.7	1143	64.9	1760
	48 - 59	31	1.9	123	7.5	370	22.6	1116	68.1	1640
		Chi Square (d.f. = 12) = 39.434, p < 0.001								
Sex of Child	Boys	93	2	373	8.2	1164	25.5	2942	64.3	4572
	Girls	103	2.4	380	8.9	1140	26.8	2638	61.9	4261
		Chi Square (d.f. = 3) = 6.445, p = 0.092								
Birth Order	1	109	3	377	10.4	1119	30.9	2013	55.6	3620
	2	50	2	203	8.2	662	26.9	1550	62.9	2464
	3	18	1.4	96	7.3	282	21.4	922	70	1318
	4 & above	19	1.3	77	5.4	241	16.9	1094	76.4	1432
		Chi Square (d.f. = 9) = 227.735, p < 0.001								
BMI	< 18.5	60	2.8	236	11.1	582	27.4	1248	58.7	2125
	18.5 -24.9	113	2	436	7.7	1473	26.1	3616	64.1	5638
	25.0 - 29.9	20	2.4	60	7.2	199	23.8	555	66.6	834
	≥ 30	1	1.1	11	8.9	24	20.1	84	70	120
		Chi Square (d.f. = 9) = 42.865, p < 0.001								
Highest Educational Level	No education	40	2.1	145	7.5	384	19.9	1363	70.6	1932
	Primary	38	2.4	144	9.1	361	22.8	1039	65.7	1582
	Secondary	107	2.2	425	8.8	1408	29.3	2871	59.7	4811
	Higher	11	2.1	39	7.7	152	29.9	306	60.3	508
		Chi Square (d.f. = 9) = 89.134, p < 0.001								
Respondent Occupation	No Occupation	19	1.6	106	9	325	27.5	732	61.9	1182
	Others	2	1.4	11	7.1	35	22.9	103	68.6	151
	Agriculture	1	1.3	10	8.8	20	17.8	83	72.1	114
	Don't Know	0	0	1	6	6	41.9	7	52.1	13
		Chi Square (d.f. = 9) = 9.993, p = 0.351								
Type of Residence	Urban	39	3	123	9.6	372	28.9	751	58.4	1285
	Rural	157	2.1	630	8.4	1932	25.6	4829	64	7548
		Chi Square (d.f. = 3) = 16.503, p < 0.001								
Wealth Index	Poorest	62	2.7	179	7.7	463	19.9	1619	69.7	2322
	Poorer	69	2.1	299	8.9	902	26.8	2096	62.3	3366
	Middle	32	1.8	155	8.9	505	29.2	1039	60	1730
	Richer	23	2.3	92	9.3	302	30.6	568	57.7	985
	Richest	10	2.4	29	6.8	133	30.8	258	59.9	430
		Chi Square (d.f. = 12) = 85.466, p < 0.001								

Birth-weight by Socio-demographic characteristics in Northeast Region

Table 4.3.42 shows the distribution of under-5 children by their birth-weight categories and socio-demographic characteristics in the Northeast Region of India. Distribution of under-5 children by their age & birth weight showed 1.7% - 2.2% children had their birth weight less than 2000 gm; 7.5% - 9.6% children had their birth weight between 2000 gm and 2499 gm; 22.6% - 28.9% children had their birth – weight between 2500 gm and 2999 gm and 60.3% - 68.1% children had their birth-weight 3000 gm and above. There is a significant correlation ($\chi^2_{df=12} = 39.434; p < 0.001$) between birthweight and age of the child. Furthermore, compared to the proportion of girls (61.9%), more boys (64.3%) had birthweights of 3000 gm or more. Similarly, more girls had their birth weight less than 3000 gm or more. The birth weight of under-5-year-old children was not shown to be significantly associated ($\chi^2_{df=3} = 6.445; p = 0.092$) by the child's sex.

Considering birth order, more children with higher birth order had birth-weight 3000 gm & above, and consequently, less number of children with higher birth order had their birth-weight less than 3000 gm & above. Birth order was found to significantly correlate $\chi^2_{df=9} = 227.735; p < 0.001$) with birth-weight in children under the age of five, similar to age. For Body Mass Index (BMI), 1.1% - 2.8%of under-5 children with different BMI scores had their birth weight less than 2000 gm; 7.2% - 11.1% of the children had their birth weight between 2000 gm and 2499 gm; 20.1% - 27.4% of the children had their birth – weight between 2500 gm and 2999 gm. As BMI scores increased, the percentage of children in these birth-weight categories reduced. Further, almost 58.7% - 70.0% of the children belonged to the birth–weight category of 3000 gm & above. Additionally, as BMI scores increased, the percentage of children increased as well. Additionally, it was found that BMI had a significant association ($\chi^2_{df=9} = 42.865; p < 0.001$) with under-5 children's birth weight.

Considering mother's highest education level, 2.1% - 2.4% of children had their birth weight less than 2000 gm; 7.5% - 9.1% of children had their birth weight ranging from 2000 gm to 2499 gm; 19.9% - 29.9% of children had their birth-weight between 2500 – 2999 gm and 59.7% - 70.6% of children had their birth – weight had their birth-weight 3000 gm & above. The highest level of education obtained by the mother was also found to be significantly related ($\chi^2_{df=9} = 89.134; p < 0.001$) to the birth weight of children under five. Additionally, our data revealed that there was no significant correlation ($\chi^2_{df=9} = 9.993; p = 0.351$) between the mother's occupation and the birthweight of children under the age of five.

The analysis further revealed that respondents' two factors – a place of residence as well as wealth index also played an important role in the determination of their birth weight. Results showed that 3% of urban and 2.1% of rural under-5 children had their birth weight less than 2000 gm; 9.6% of urban and 8.4% of rural had their birth weight between 2000 gm and 2499 gm; 28.9% of urban and 25.6% of rural had their birth-weight between 2500 gm and 2999 gm. For all birth-weight groups less than 3000 gm, the percentage of under-5 children was more in urban than rural areas. For the birth-weight group of 3000 gm and above, however, the situation was quite the opposite. Place of residence was significantly correlated ($\chi^2_{df=3} = 16.503; p < 0.001$) with birth-weight of the under-5 children. For the wealth index also, our analysis revealed that the percentage of under-5 children in various wealth index categories increased with an increase in their wealth status for all birth-weight categories below 3000 gm & above. For the birth-weight group of 3000 gm and above, however, the scenario was quite the opposite. The wealth index of the under-5 children and their birth weight were significantly correlated ($\chi^2_{df=12} = 85.466; p < 0.001$).

4.3.7.1 Growth Estimation of Under-5 Children Using Statistical Model

In order to estimate the growth curves, all 11 statistical models were fitted to the height and weight data of children under the age of 5 from the Northeast Region of India, taking into account their ages (months) for each of the four birth-weight groups independently. Our analysis revealed that, when using the best-fit model criterion, only two statistical models—*Cubic Model* and *Power Model*—showed the best fit to the height and weight data of under-5-year-olds children who fell into the various birth-weight categories, allowing us to estimate the growth of boys and girls separately. Here, the results of only two best-fit models have been shown below *(Tables 4.3.43 and 4.3.44).*

Table 4.3.43 describes the model summary for the height of boys and girls by their birthweight categories. Here, for the height of the boys, considering the Coefficient of Determination (R^2) as the criterion for the best fit, the *Power Model* fitted best for the birth-weight group less than 2000 gm ($R^2 = 0.829$), followed by the birth-weight group 2000 – 2499 gm ($R^2 = 0.762$), but for the rest of the two birth-weight groups, the *Cubic Group* is fitted best. Thus, here, as per the Coefficient of Determination (R^2), *Cubic Model* fitted best for birth-weight group 2500 – 2999 gm ($R^2 = 0.805$), followed by the birth-weight group 3000 gm & above ($R^2 = 0.779$). For the height of the girls, *Power Model* fitted best for birth-weight 2000 – 2499 gm ($R^2 = 0.814$), followed by the group with less than 2000 gm ($R^2 = 0.800$), but for the rest of the two birth-weight groups, the *Cubic Model* fitted best. Thus, here, as per the Coefficient of Determination (R^2), Cubic Model fitted best for the birth-weight 2500 – 2999 gm ($R^2 = 0.799$), followed by group 3000 gm and above ($R^2 = 0.782$).

Table 4.3.43: Model's summary for Height of Boys & Girls by their Birthweight categories

Birthweight	Model	R^2	Constant	d.f.		F	b_1	b_2	b_3
				Regression	Residuals				
Boys									
< 2000	Power	0.829	45.438	1	180	872.8	0.188		
2000 - 2499	Power	0.762	47.075	1	955	3631.2	0.180		
2500 - 2999	Cubic	0.805	55.913	3	3057	4217.6	1.692	-0.029	0.0002
3000 +	Cubic	0.779	56.627	3	12878	15126.8	1.686	-0.029	0.0002
Girls									
< 2000	Power	0.800	44.125	1	191	762.7	0.192		
2000 - 2499	Power	0.814	47.935	1	995	4358.3	0.171		
2500 - 2999	Cubic	0.799	54.850	3	3283	4344.2	1.654	-0.027	0.0002
3000 +	Cubic	0.782	55.815	3	11837	14133.5	1.584	-0.024	0.0001

Table 4.3.44 describes the model summary for the weight of boys and girls by their birthweight categories. For the weight of the boys as well as girls, the best-fitted model was Power Model. Further, considering boys, as per coefficient of Determination (R^2), *Power Model* fitted best for birth-weight group less than 2000 gm ($R^2 = 0.798$), followed by group 2000 – 2499 gm ($R^2 = 0.784$), group 2500 – 2999 gm ($R^2 = 0.759$) and the birthweight group of 3000 gm & above ($R^2 = 0.721$). For estimating the weight of the girls, *Power Model* fit best for birth-weight group 2000 – 2499 gm ($R^2 = 0.785$), followed by group less than 2000 gm ($R^2 = 0.781$), group 2500 – 2999 gm ($R^2 = 0.780$), and the birth-weight group ($R^2 = 0.737$).

Table 4.3.44: Model's summary for Weight of Boys & Girls by Birthweight categories

Birthweight	**Model**	**R^2**	**Constant**	**d.f.**		**F**	**b_1**
Boys				**Regression**	**Residuals**		
< 2000	Power	0.798	3162.889	1	183	722.621	0.362
2000 - 2499	Power	0.784	3305.449	1	969	3515.328	0.361
2500 - 2999	Power	0.759	3827.343	1	30886	9742.698	0.321
3000 +	Power	0.721	4246.5230	1	12995	33623.279	0.301
Girls							
< 2000	Power	0.781	2826.825	1	195	696.733	0.377
2000 - 2499	Power	0.785	3422.681	1	1008	3671.150	0.338
2500 - 2999	Power	0.780	3497.572	1	3330	11774.334	0.337
3000 +	Power	0.737	3851.423	1	11937	33489.402	0.318

4.3.7.2 Estimation of Height & Weight of Under 5 Children at Different Birthweight Categories

We estimated growth curves – considering mean height and mean weight of under-5 children for their ages – ranging from 1 to 59 months, considering all four birth-weight groups by using *Cubic Mode*l or *Power Model* which ever fitted best under the situation, for boys and girls separately. As a result, growth charts were created, separately for the two sexes and for each birth weight group, illustrating the height and weight curves. For each of the four birth-weight groups separately, *Figures 4.3.5(a) to 4.3.5(d)* show the estimated mean height and mean weight curves of boys. Similarly, estimated mean height and mean weight of girls are shown separately for each of the four birth-weight groups in *Figures 4.3.6(a) to 4.3.6(d).* The graphs displayed here include curves for both the upper and lower 95% confidence limits in addition to estimated mean height and weight curves for each case.

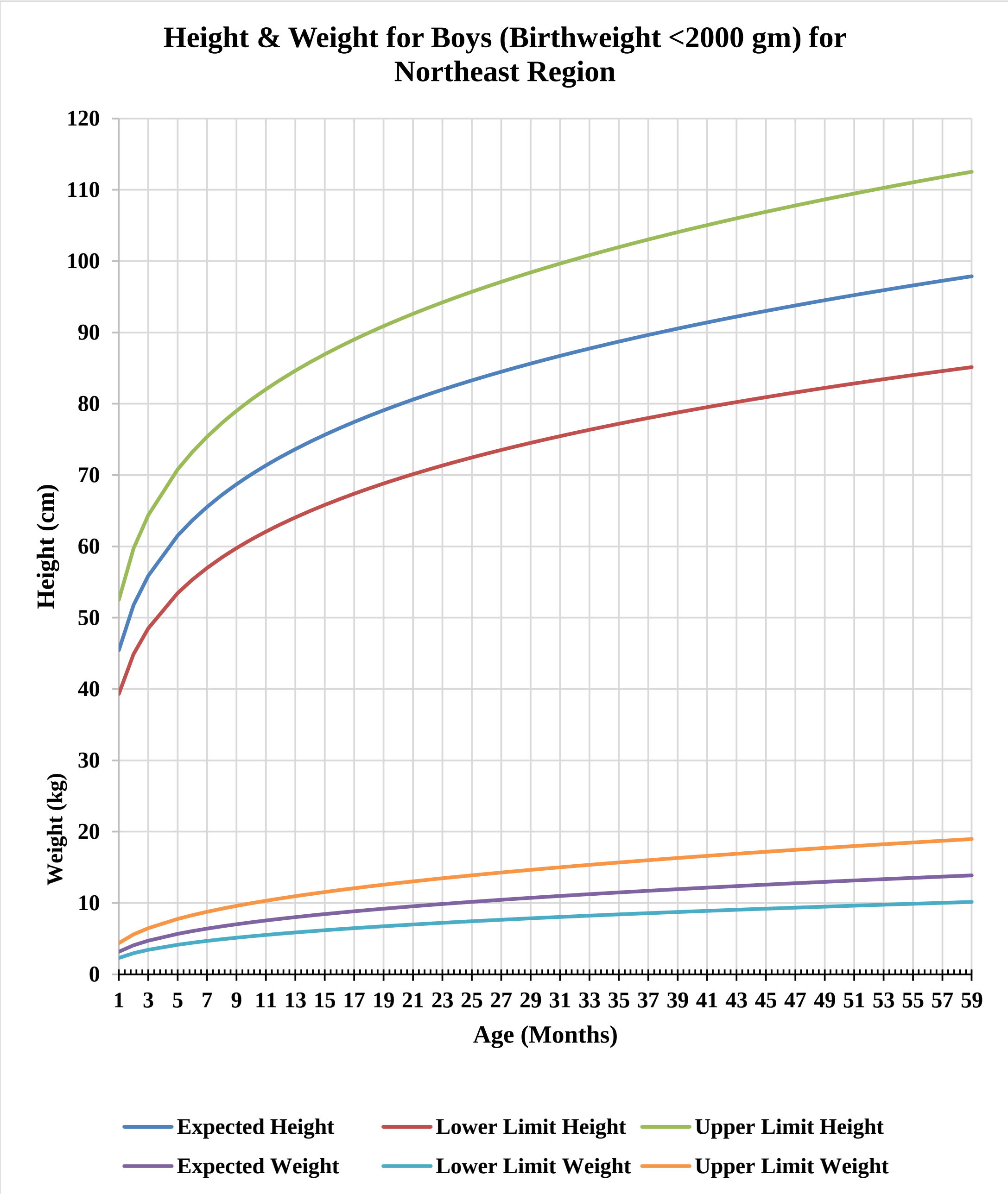
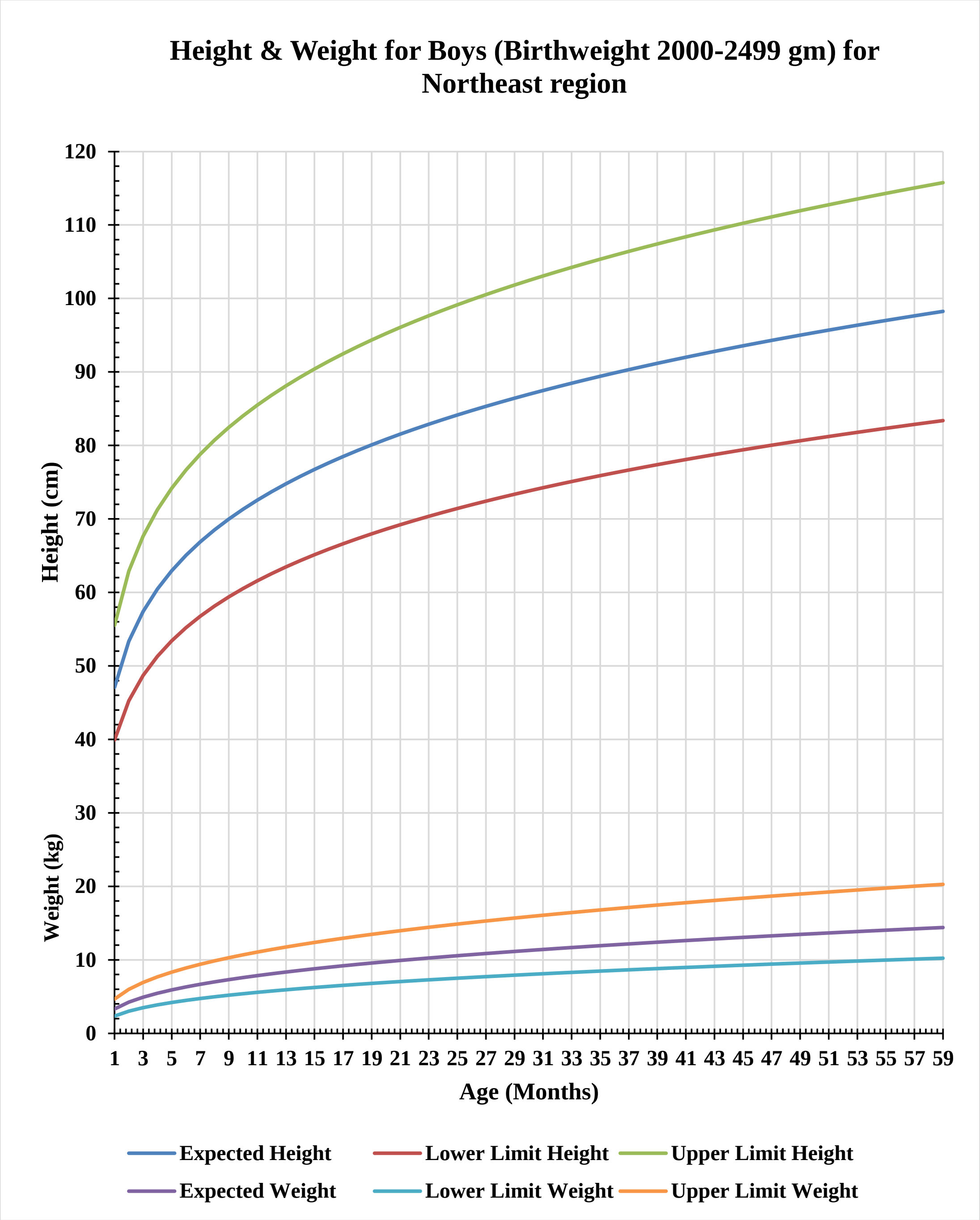


Figure 4.3.5(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Boys of Northeast Region (India), Using Power Model



$Figure$ 4.3.5(b): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Boys of Northeast Region (India), Using Power Model

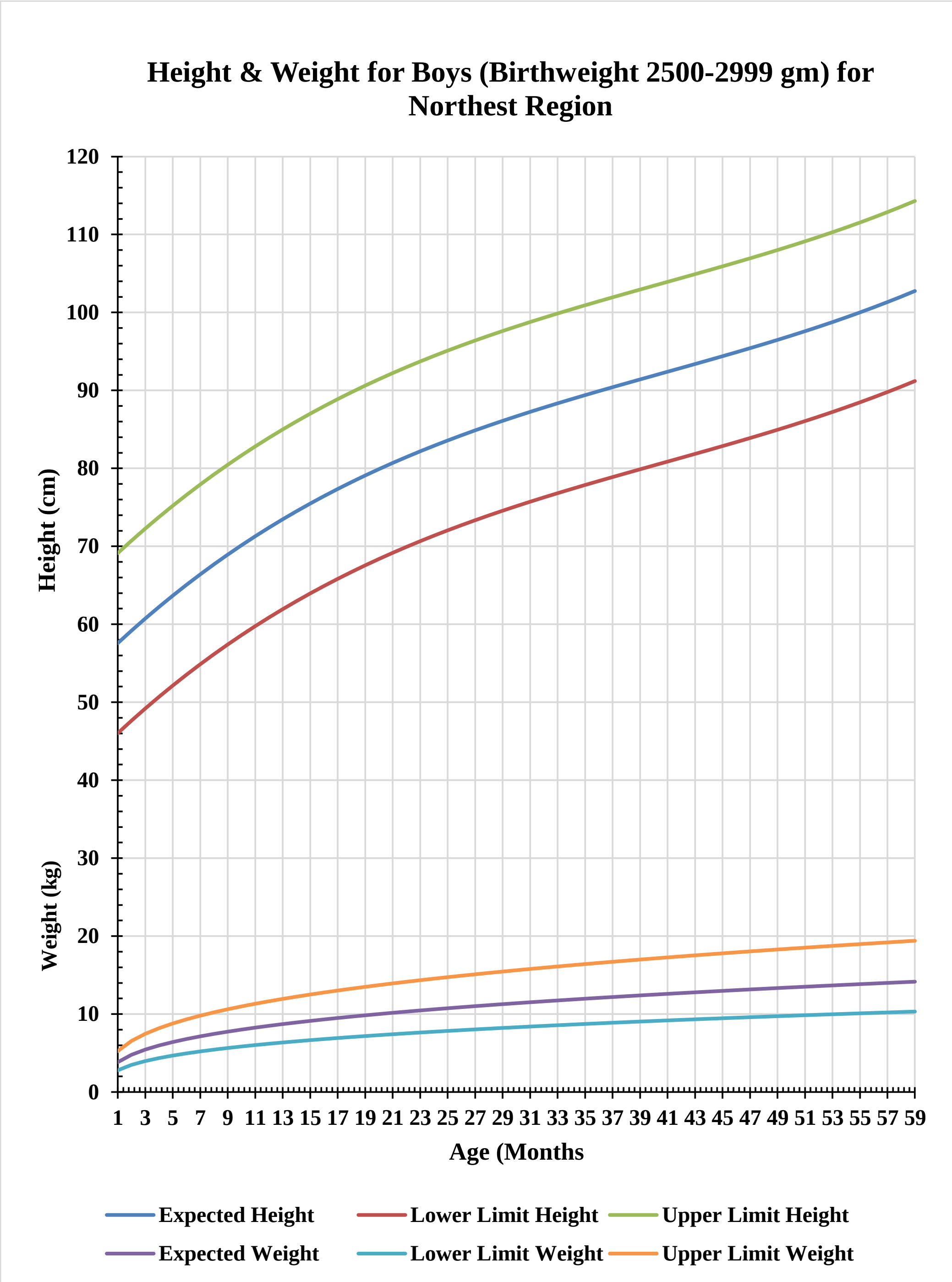


Figure 4.3.5(*c*): NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Boys Northeast Region (India), Using Cubic and Power Model, respectively

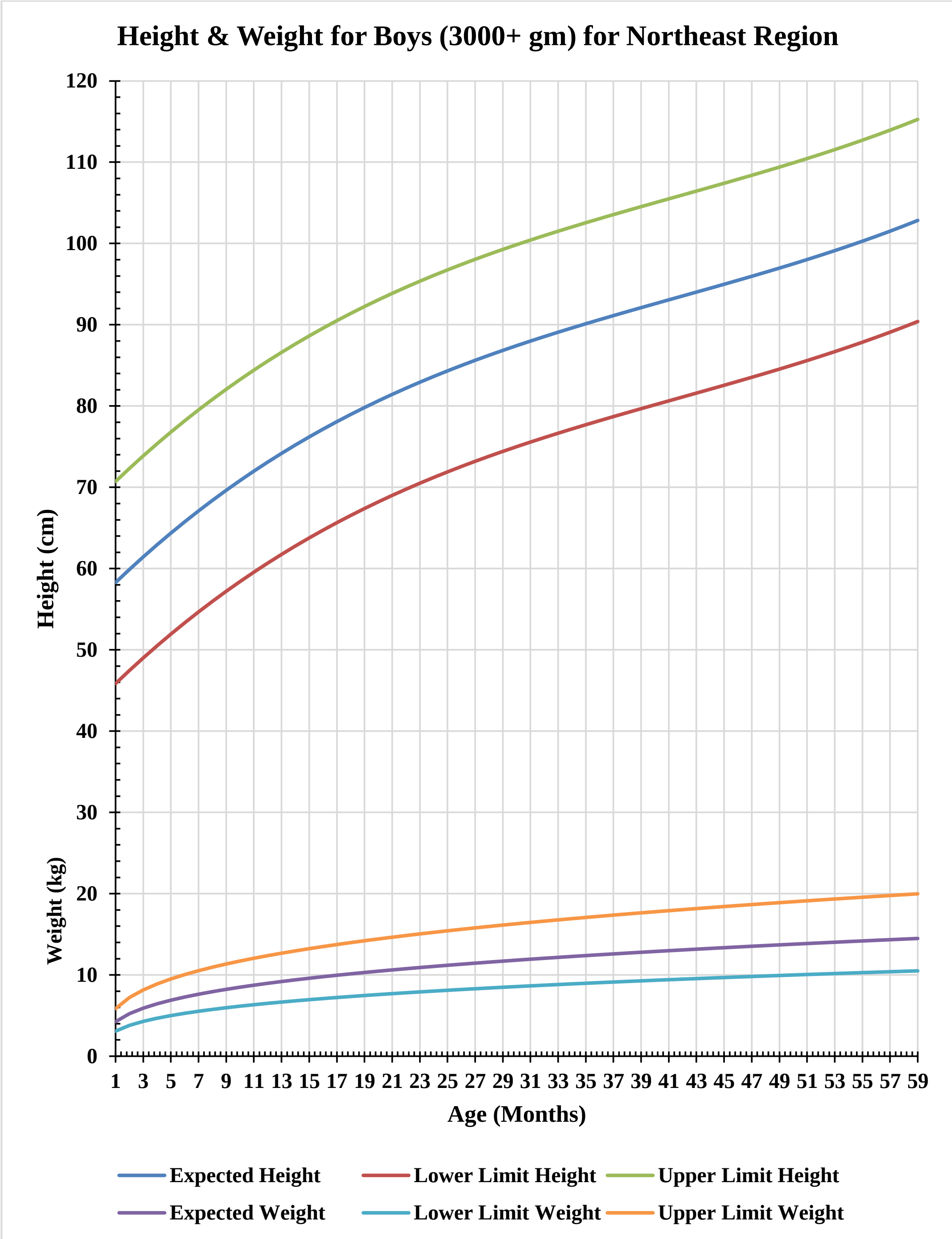
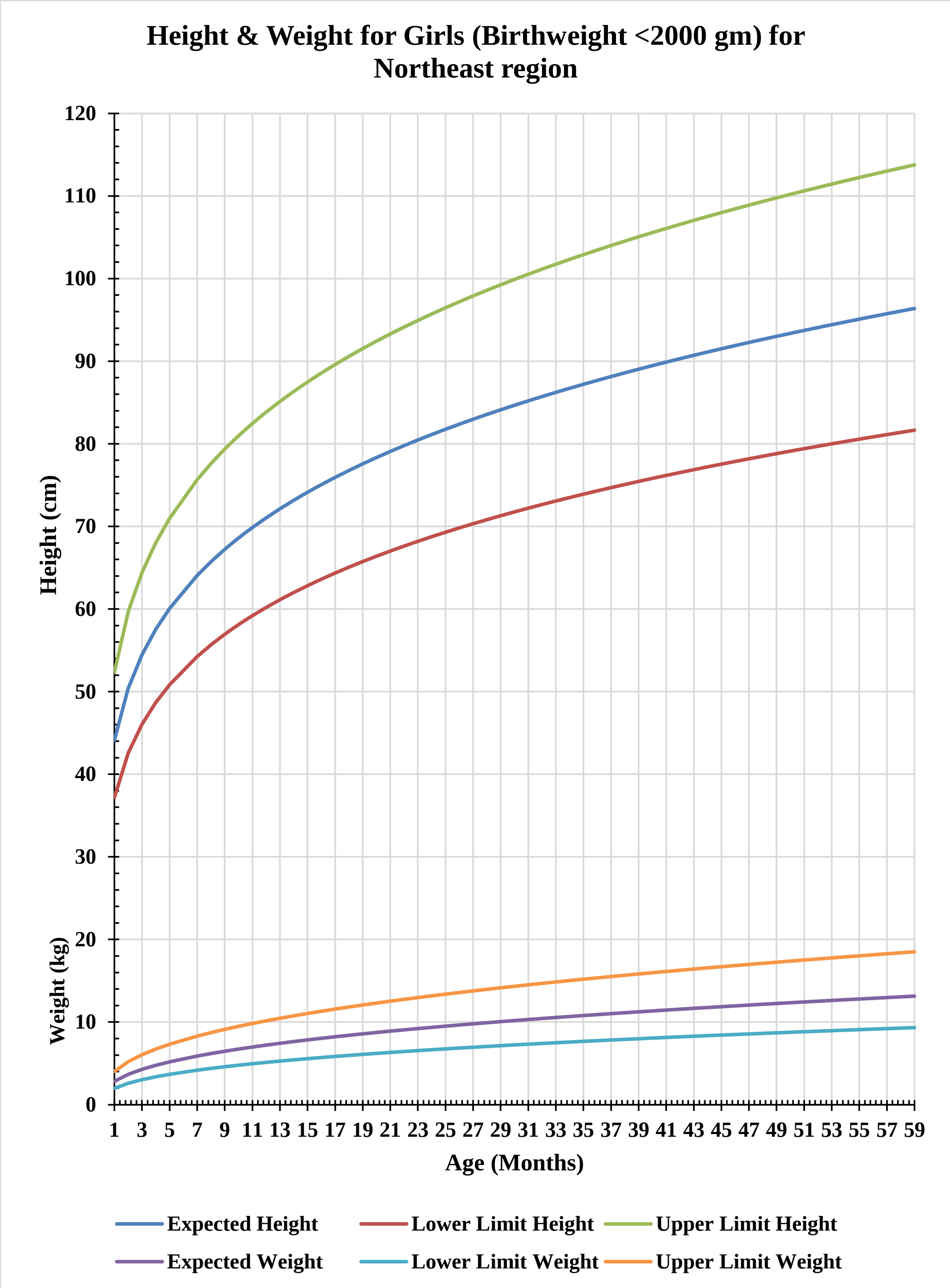


Figure 4.3.5(*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Boys Northeast Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.3.6(a): NFHS-4 (Birth-weight < 2000 gm): Estimated Height & Weight Curves for Girls Northeast Region (India), Using Power Model

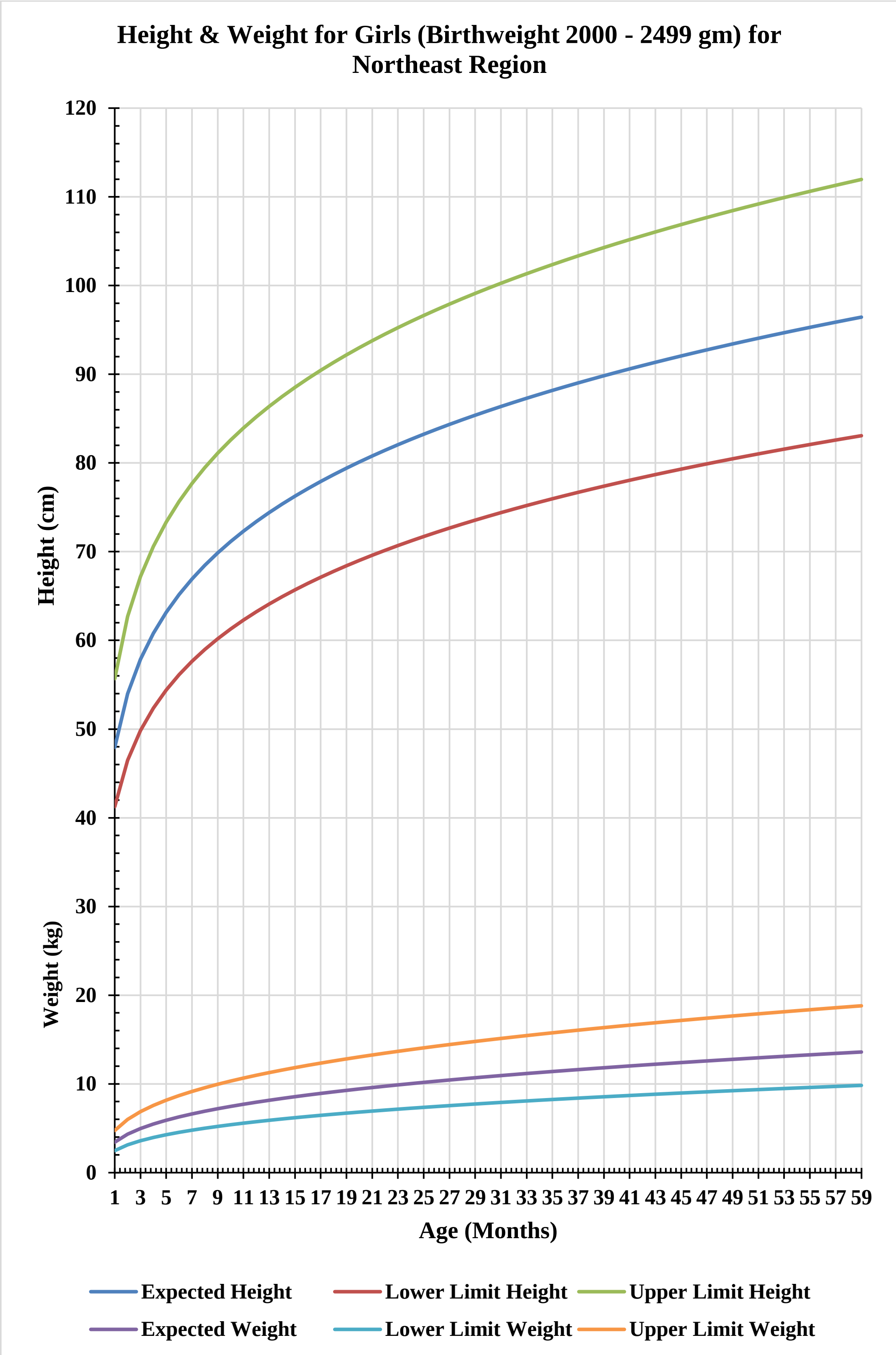


Figure 4.3.6(*b*): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Girls Northeast Region (India), Using Power Model

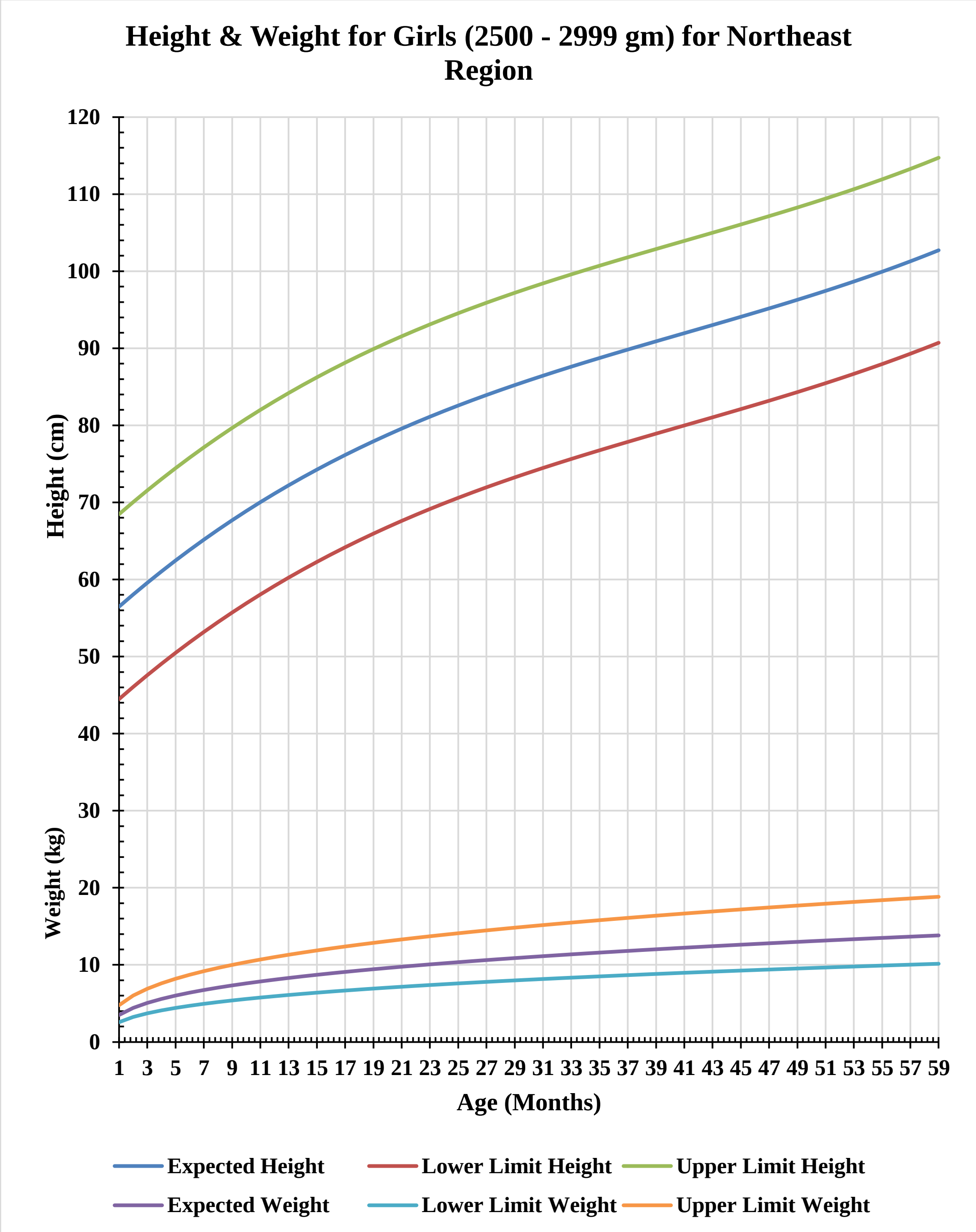


Figure 4.3.6(*c*): NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Girls Northeast Region (India), Using Cubic and Power Model, respectively

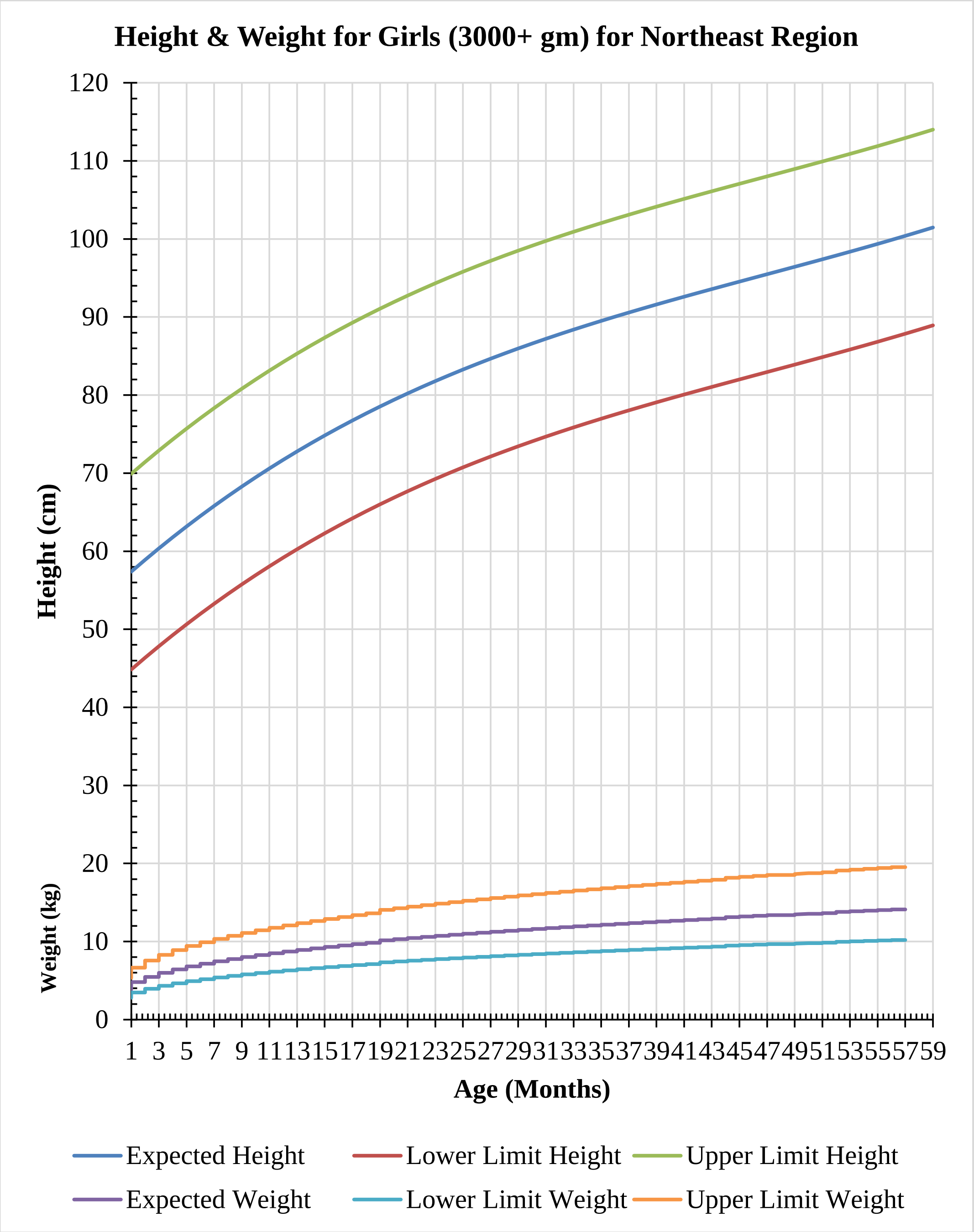


Figure 4.3.6(*d*): NFHS-4 (Birth-weight 3000 + gm): Estimated Height & Weight Curves for Girls Northeast Region (India), Using Cubic and Power Model, respectively

4.4 Northern Region

This Region consists of 6 States & UTs, namely – Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttarakhand.

4.4.1 Status of Under-Nutrition

Table 4.4.1: Prevalence rates (%) of stunting, wasting, and underweight.

	Stunting	Wasting	Underweight
Northern Region	**29.1**	**16.9**	**24.9**
Chandigarh	28.7	10.9	24.5
Delhi	31.9	15.9	27.0
Haryana	34.0	21.2	29.4
Himachal Pradesh	26.3	13.7	21.2
Jammu & Kashmir	27.4	12.1	16.6
Punjab	25.7	15.6	21.6
Rajasthan	39.1	23.0	36.7
Uttarakhand	33.5	19.5	26.6

Figure 4.4.1: Prevalence rates (%) of stunting, wasting, and underweight.

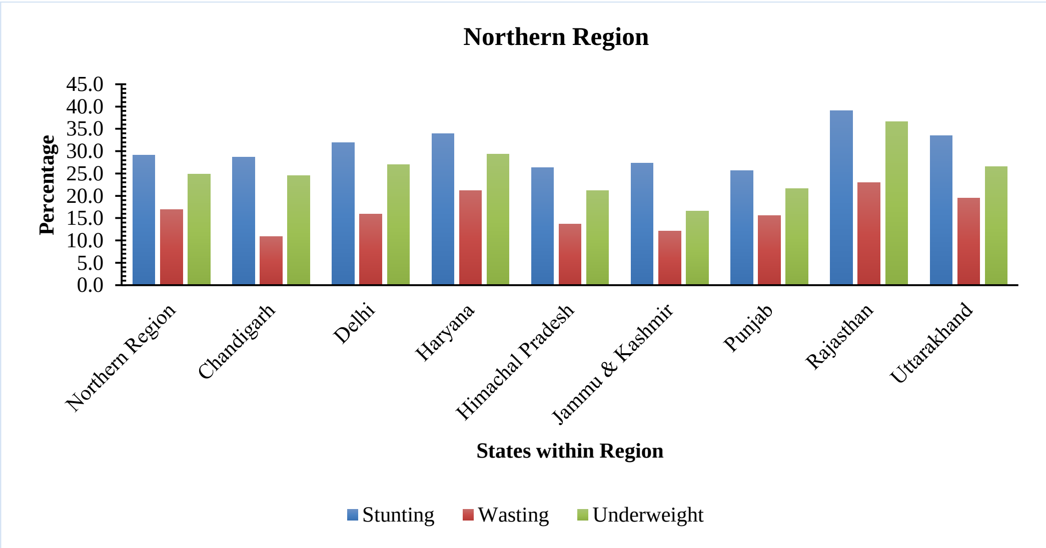


Table 4.4.1 and Figure 4.4.1 display the prevalence rates of stunting, wasting, and underweight in the Northern Region. Stunting varies from 25.7% in Punjab to 39.1% in Rajasthan. Rajasthan also exhibits the highest wasting rate at 23.0%, while Chandigarh has the lowest at 10.9%. The prevalence of underweight is notably high at 36.7% in Rajasthan, contrasting with a lower rate of 16.6% in Jammu & Kashmir.

4.4.2 Stunting

Table 4.4.2: - Odds Ratio of Stunting in Under-5 Children by socio-demographic variables in Northern Region of India

Socio - demographic Variables	**p - value**	**OR**	**95% C.I.for OR**	
			Lower Limit	**Upper Limit**
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.47	2.26	2.69
24 - 35	0.000	2.25	2.07	2.45
36 - 47	0.000	2.31	2.12	2.51
48 - 59	0.000	1.89	1.74	2.06
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.15	1.10	1.21
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.22	1.99	2.47
Poorer	0.000	1.82	1.66	2.00
Middle	0.000	1.49	1.37	1.63
Richer	0.000	1.26	1.17	1.37
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.64	1.47	1.83
Primary	0.000	1.50	1.34	1.68
Secondary	0.000	1.30	1.18	1.43
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	0.85	0.80	0.90
Birth Order				
1 *(Ref)*		1.00		
2	0.000	1.15	1.08	1.22
3	0.000	1.17	1.08	1.26
4 & above	0.000	1.29	1.18	1.40
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.30	1.22	1.39
Overweight	0.000	0.79	0.72	0.85
Obese	0.051	0.87	0.75	1.00

Table 4.4.2 shows odds ratio of stunting in children under the age of five by socio-demographic variables in India's northern region. In comparison to the age group below 12 months, the odds of having stunted children were 2.4 times higher in the age group 12 to 23 month (OR: 2.47; 95% CI: 2.26 – 2.69; $p < 0.001$). When compared to children under the age of 12 months, the odds of having stunted children were 2.2 times higher in the age range of 24 to 35 months (OR: 2.25; 95% CI: 2.07 – 2.45; $p < 0.001$). The odds of having stunted children were 2.3 times higher in the age group of 36 to 47 months (OR: 2.31; 95% CI: 2.12 – 2.51; $p < 0.001$) as compared to children under the age of 12 months. When compared to children under the age of 12 months, the odds of having stunted children were 1.8 times higher in the age group of 48 to 59 months (OR: 1.89; 95% CI: 1.74 – 2.06; $p < 0.001$). Male children (OR: 1.15; 95% CI: 1.10 – 1.21; $p < 0.001$) had significantly higher odds of stunting than female children.

The odds of stunted children were 2.2 times higher in the poorest group (OR: 2.22; 95% CI: 1.99 – 2.47; $p < 0.001$) than in the richest group. The odds of stunted children were 1.8 times higher in the poorer group (OR: 1.82; 95% CI: 1.66 – 2.00; $p < 0.001$) than in the richest group. In comparison to the richest group, the middle group (OR: 1.49; 95% CI: 1.37 – 1.63; $p < 0.001$) has 1.4 times higher odds of stunted children. In the richer group (OR: 1.26; 95% CI: 1.17 – 1.37; $p < 0.001$) compared to the richest group, the odds of stunted children were 1.2 times greater.

The odds of having stunted children were 1.6 times greater for mothers with no education (OR: 1.64; 95% CI: 1.47 – 1.83; $p < 0.001$) than for those with higher levels of education. The odds of having stunted children were 1.5 times greater for women with only primary education (OR: 1.50; 95% CI: 1.34 – 1.68; $p < 0.001$)

compared to those with higher levels of education. The odds of having stunted children were 1.3 times greater for women with secondary education (OR: 1.30; 95% CI: 1.18 – 1.43; $p < 0.001$) compared to those with higher levels of education. As compared to urban regions, children in rural areas (OR: 0.85; 95% CI: 0.80 – 0.90; $p < 0.001$) had 15% lower odds of stunting.

Children born in the second (OR: 1.15; 95% CI: 1.08 – 1.22; $p < 0.001$) and third birth orders (OR: 1.17; 95% CI: 1.08 – 1.26; $p < 0.001$) had 1.1 times greater odds of being stunted in comparison to the first birth order. In comparison to the first birth order, children in birth orders 4 and upwards (OR: 1.29; 95% CI: 1.18 – 1.40; $p < 0.001$) had 1.2 times greater odds of being stunted. Underweight mothers (OR: 1.30; 95% CI: 1.22 – 1.39; $p < 0.001$) had 1.3 times higher odds of giving birth to children who were stunted compared to those with a normal mother. Overweight mothers (OR: 0.79; 95% CI: 0.72 – 0.85; $p < 0.001$) had 21% lower odds of giving birth to children who were stunted than normal mothers. Obese mothers had 13% lower odds of giving birth to children who were stunted than those with a normal mother.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model are shown in Table 4.4.3 at 61.3%. However, depending on the demands of the study and the requirement for diagnostic research, sensitivity and specificity might be altered. Area under the ROC curve is 0.652 (95% CI: - 0.647 – 0.658) (Figure 4.4.2).

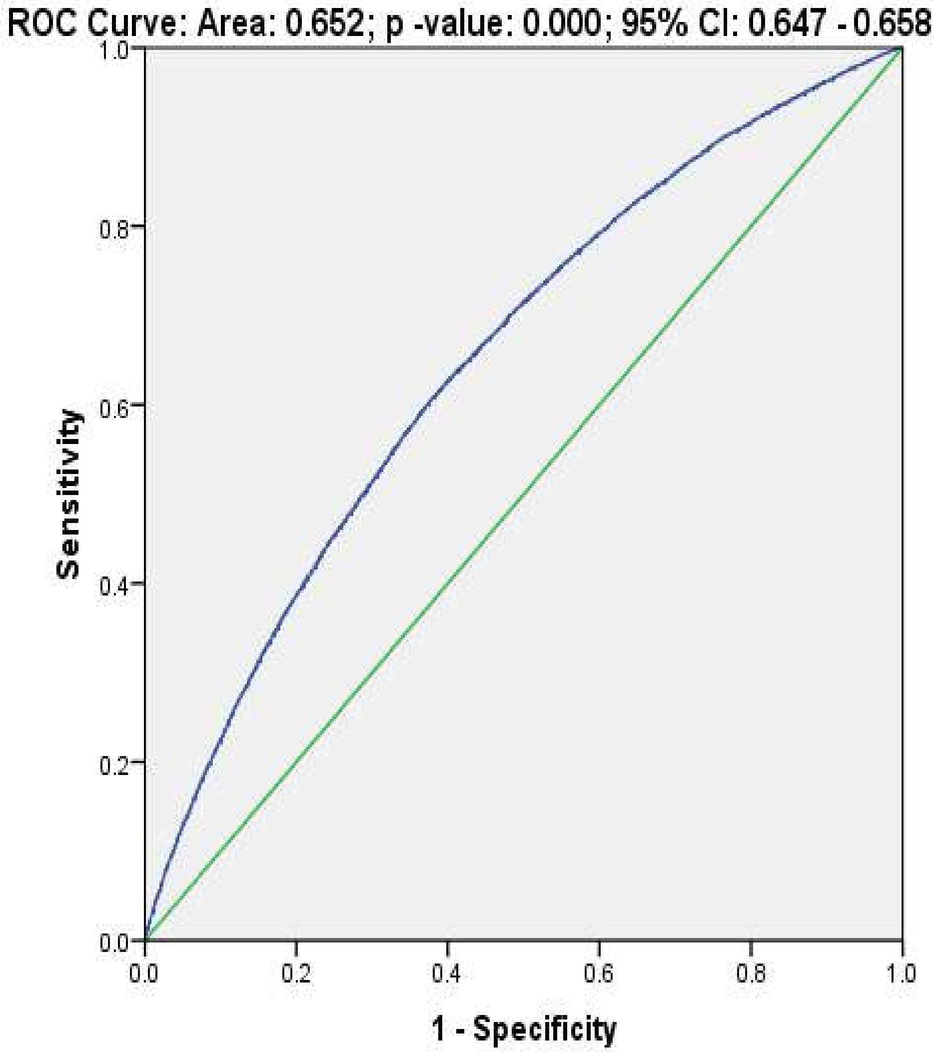


Figure 4.4.2: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Stunting in Northern Region of India

Table 4.4.3: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.172331	0.969	0.085
0.182677	0.959	0.109
0.196601	0.949	0.129
0.201765	0.939	0.151
0.214035	0.929	0.173
0.221299	0.919	0.195
0.226727	0.909	0.215
0.237313	0.899	0.236
0.239780	0.889	0.253
0.243250	0.879	0.268
0.249564	0.869	0.286
0.255970	0.859	0.302
0.259824	0.849	0.315
0.266121	0.839	0.332
0.270034	0.828	0.351
0.294367	0.769	0.432
0.298441	0.759	0.444
0.303002	0.749	0.456
0.305661	0.739	0.469
0.310330	0.728	0.483
0.315901	0.719	0.495
0.318894	0.709	0.507
0.320537	0.699	0.519
0.326785	0.675	0.544
0.334347	0.659	0.562
0.354074	**0.613**	**0.613**
0.356912	0.601	0.626
0.357855	0.597	0.630
0.358203	0.596	0.630
0.416952	0.421	0.774
0.418003	0.418	0.776
0.437267	0.368	0.814
0.439964	0.358	0.821
0.505696	0.180	0.925
0.523904	0.140	0.945

4.4.3 Wasting

Table 4.4.4: - Odds Ratio of Wasting in Under-5 Children by socio-demographic variables in the Northern Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Month)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	0.61	0.57	0.66
24 - 35	0.000	0.67	0.62	0.72
36 - 47	0.000	0.59	0.55	0.63
48 - 59	0.000	0.60	0.55	0.64
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.13	1.08	1.19
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	1.48	1.34	1.64
Poorer	0.002	1.15	1.05	1.26
Middle	0.496	1.03	0.95	1.12
Richer	0.991	1.00	0.93	1.08
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.003	1.17	1.05	1.29
Primary	0.020	1.14	1.02	1.26
Secondary	0.982	1.00	0.92	1.09
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	0.84	0.79	0.89
Birth Order				
1 *(Ref)*		1.00		
2	0.081	1.05	0.99	1.12
3	0.525	1.03	0.95	1.10
4 & above	0.578	0.98	0.90	1.06
BMI (Kg/m^2)				
Normal *(Ref)*		1.00		
Underweight	0.000	1.29	1.22	1.37
Overweight	0.000	0.62	0.57	0.67
Obese	0.000	0.53	0.45	0.62

Table 4.4.4 represents the odds ratio of wasting in under-5 children by socio-demographic variables in the northern region of India. As compared to children under the age of 12 months, those aged 12 to 23 months (OR: 0.61; 95% CI: 0.57 – 0.66; p < 0.001) had a 39% less odds of being wasted. In comparison to children under the age of 12 months, children in the age group of 24 to 35 months (OR: 0.67; 95% CI: 0.62 – 0.72; p < 0.001) had 33% lesser odds of being wasted. In comparison to children under the age of 12 months, children in the age group of 36 to 47 months (OR: 0.59; 95% CI: 0.55 – 0.63; p < 0.001) had 41% lower odds of being wasted. In comparison to children under the age of 12 months, children in the age period 48 to 59 months (OR: 0.60; 95% CI: 0.55 – 0.64; p < 0.001) had 40% lesser odds of being wasted. Children who were wasted had a significantly higher odds of being female (OR: 1.13; 95% CI: 1.08 – 1.19; p < 0.001) than males.

For the poorest group (OR: 1.48; 95% CI: 1.34 – 1.64; p < 0.001) compared to the richest group, the odds of being wasted was 1.4 times higher. For the poorer group (OR: 1.15; 95% CI: 1.05 – 1.26; p < 0.002) compared to the richest group, the odds of being wasted were significantly more. For both the middle group (OR: 1.03; 95% CI: 0.95 – 1.12; p = 496) and richer group (OR: 1.00; 95% CI: 0.93 – 1.08; p = 0.991) compared to the richest group, the odds of being wasted was significantly higher. There is no substantial difference in the likelihood of wasted children when comparing the Richer group and the Middle group with the Richest Group.

As comparison to mothers with higher levels of education, mothers with only primary education (OR: 1.14; 95% CI: 1.02 – 1.26; p = 0.020) and no further education (OR: 1.17; 95% CI: 1.05 – 1.29; p = 0.003) had significantly greater odds of having wasted children. In comparison with mothers with higher levels of education to mothers with secondary education (OR: 1.00; 95% CI: 0.92 – 1.09; p = 0.982), the odds of having wasted children were significantly increased. When mothers with secondary education are compared to mothers with higher levels of education, there is no noticeable difference in the chance of wasted children. There were 16% lesser odds of wasted children in rural areas (OR: 0.84; 95% CI: 0.79 – 0.89; $p < 0.001$) than in urban areas.

The odds of having wasted children was significantly higher in the second birth order (OR: 1.05; 95% CI: 0.99 – 1.12; p = 0.081) than in the first birth order. In the third birth order (OR: 1.03; 95% CI: 0.95 – 1.10; p = 0.525) compared to the first, the odds of having wasted children was significantly higher. In birth orders four and above (OR: 0.98; 95% CI: 0.90 – 1.06; p = 0.578) compared to the first birth order, there were 2% lesser odds of having wasted children. When comparing other Birth Orders with the First Birth Order, there is no noticeable variation in the number of wasted children.

Underweight mothers (OR: 1.29; 95% CI: 1.22 – 1.37; $p < 0.001$) had 1.2 times greater odds of having wasted children than normal mothers. In comparison to normal mothers, overweight mothers (OR: 0.62; 95% CI: 0.57 – 0.67; $p < 0.001$) had 38% lesser odds of having wasted children. In comparison to normal mothers, obese mothers had a 47% less odds of having wasted children.

Diagnostic Evaluation of Logistic Regression

The sensitivity and specificity of the model is 56.6%, according to Table 4.4.5. However, according to the objectives of the study and the necessity for diagnostic research, sensitivity and specificity may alter. Area under the ROC curve is 0.601 (95% CI: 0.595 – 0.608) (Figure 4.4.3).

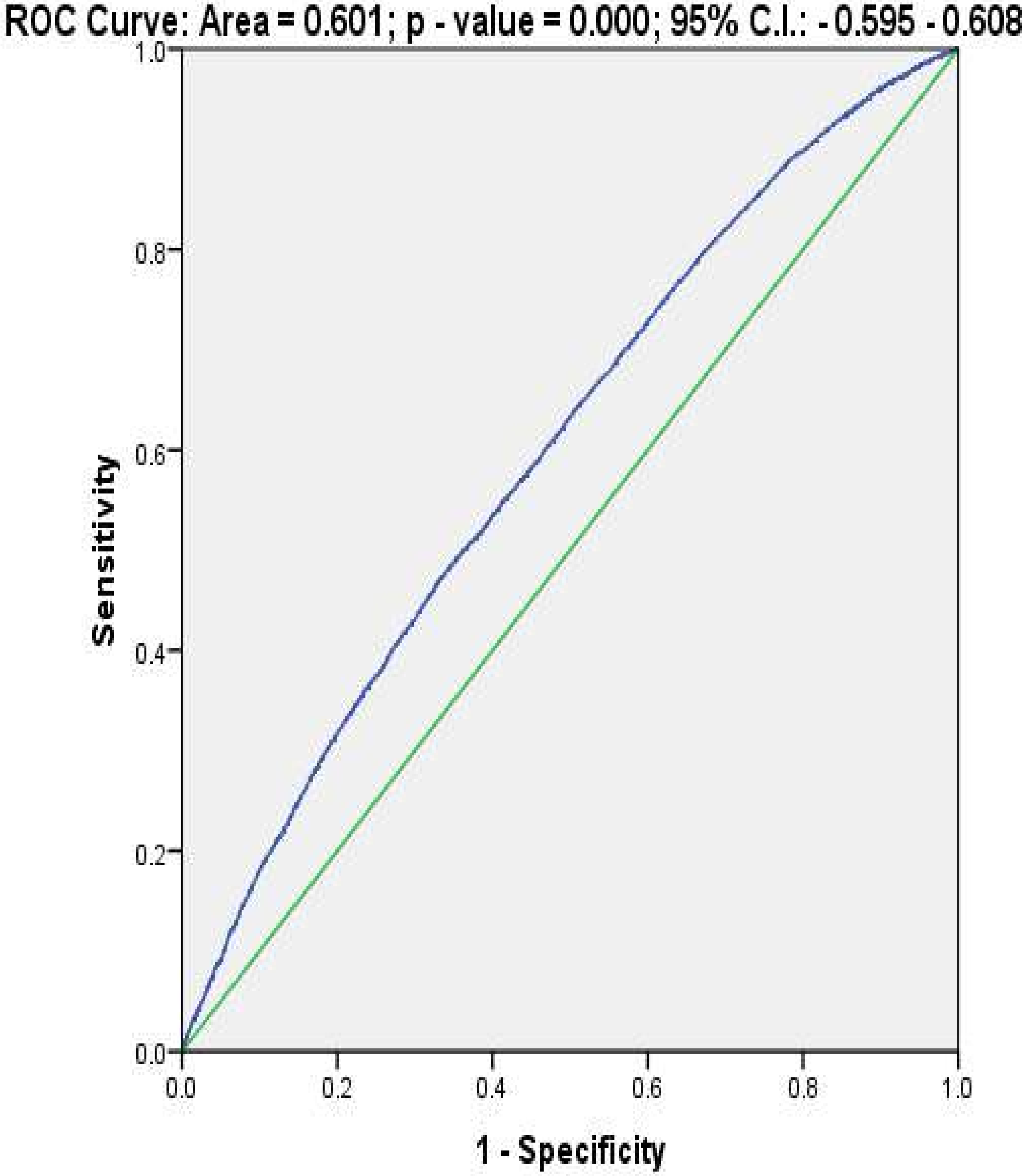


Figure 4.4.3: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Wasting in the Northern Region of India

Table 4.4.5: - Sensitivity & Specificity of the Model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.108363	0.970	0.078
0.108931	0.969	0.079
0.116745	0.959	0.102
0.121088	0.949	0.118
0.127553	0.939	0.135
0.157412	0.847	0.267
0.158541	0.837	0.279
0.159579	0.829	0.289
0.160531	0.818	0.302
0.161805	0.808	0.315
0.162218	0.798	0.327
0.163683	0.788	0.337
0.165464	0.776	0.349
0.165925	0.767	0.360
0.167405	0.758	0.369
0.169144	0.749	0.378
0.178377	0.669	0.462
0.178951	0.658	0.473
0.180015	0.648	0.484
0.181495	0.639	0.494
0.182481	0.629	0.503
0.183742	0.615	0.516
0.184322	0.608	0.524
0.185734	0.600	0.533
0.185776	0.599	0.533
0.186871	0.588	0.542
0.191392	**0.566**	**0.566**
0.197314	0.526	0.607
0.197908	0.517	0.616
0.218273	0.408	0.722
0.220562	0.387	0.737
0.240733	0.291	0.821
0.245074	0.263	0.840
0.283854	0.121	0.936
0.286960	0.111	0.941

4.4.4 Underweight

Table 4.4.6: - Odds Ratio of Underweight in Under-5 Children by socio-demographic variables in the Northern Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Month)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	1.15	1.06	1.23
24 - 35	0.000	1.38	1.29	1.48
36 - 47	0.000	1.39	1.30	1.49
48 - 59	0.000	1.51	1.40	1.62
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.12	1.072	1.17
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.33	2.12	2.56
Poorer	0.000	1.62	1.50	1.76
Middle	0.000	1.31	1.22	1.41
Richer	0.000	1.18	1.10	1.27
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.69	1.53	1.86
Primary	0.000	1.71	1.55	1.89
Secondary	0.000	1.30	1.20	1.42
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	0.77	0.73	0.81
Birth Order				
1 *(Ref)*		1.00		
2	0.000	1.15	1.09	1.21
3	0.000	1.15	1.07	1.23
4 & above	0.000	1.22	1.13	1.31
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.75	1.66	1.84
Overweight	0.000	0.62	0.58	0.67
Obese	0.000	0.56	0.48	0.64

Table 4.4.6 shows the odds ratio of underweight in children under the age of five by socio-demographic variable in India's northern region. Underweight children were significantly higher in the age group 12 – 23 months (OR: 1.15; 95% CI: 1.06 – 1.23; p < 0.001) compared to children under the age of 12 months. Underweight children were 1.3 times higher in aged group 24 – 35 months (OR: 1.38; 95% CI: 1.29 – 1.48; p < 0.001) and 36 – 47 months (OR: 1.39; 95% CI: 1.30 – 1.49; p < 0.001) compared to children under the age of 12 months. Underweight children were 1.5 times higher in the age group 48 – 59 months (OR: 1.51; 95% CI: 1.40 – 1.62; p < 0.001) compared to children under the age of 12 months. As compared to female children, male children (OR: 1.12; 95% CI: 1.07 – 1.17; p < 0.001) had significantly higher odds of being underweight.

The odds of having underweight children were 2.3 times greater in the poorest group (OR: 2.33; 95% CI: 2.12 – 2.56; p < 0.001) compared to the richest group. The odds of having underweight children were 1.6 times greater in the poorer group (OR: 1.62; 95% CI: 1.50 – 1.76; p < 0.001) than in the richest group. The odds of having underweight children were 1.3 times greater in the middle group (OR: 1.31; 95% CI: 1.22 – 1.41; p < 0.001) than in the richest group. Richer groups (OR: 1.18; 95% CI: 1.10 – 1.27; p < 0.001) had significantly higher risk of having underweight children than the Richest groups.

Mothers with no education (OR: 1.69; 95% CI: 1.53 – 1.86; p < 0.001) compared to mothers with higher levels of education, the odds of having underweight children were 1.6 times higher. Mothers with primary education (OR: 1.71; 95% CI: 1.55 – 1.89; p < 0.001) had 1.7 times greater odds of having underweight children than mothers with higher levels of education. As compared to mothers with higher levels of education, mothers with secondary education (OR: 1.30; 95% CI: 1.20 – 1.42; $p < 0.001$) had 1.3 times the odds of having underweight children. In comparison to urban regions, there was 23% lower odds of underweight children in rural areas (OR: 0.77; 95% CI: 0.73 – 0.81; $p < 0.001$).

In comparison to the first birth order, the odds of having underweight children were significantly more in the second (OR: 1.15; 95% CI: 1.09 – 1.21; $p < 0.001$) and third birth orders (OR: 1.15; 95% CI: 1.07 – 1.23; $p < 0.001$). In the birth order 4 and above (OR: 1.22; 95% CI: 1.13 – 1.31; $p < 0.001$) compared to the first birth order, the odds of a children being underweight were 1.2 times higher. In comparison to normal mothers, underweight mothers (OR: 1.75; 95% CI: 1.66 – 1.84; $p < 0.001$) had 1.7 times higher odds of having underweight children. In comparison to normal mothers, overweight mothers (OR: 0.62; 95% CI: 0.58 – 0.67; $p < 0.001$) had 38% lesser odds of having underweight children. In comparison to normal mothers, obese mothers (OR: 0.56; 95% CI: 0.48 – 0.64; $p < 0.001$) had 44% lower odds of having underweight children.

Diagnostic Evaluation of Logistic Regression

The model's sensitivity and specificity are 61.3% and 61.4%, respectively, according to Table 4.4.7. Sensitivity and specificity, however, may change based on the needs of the research and the need for diagnostic research. Area under the ROC curve is 0.656 (95% CI: 0.651 – 0.662) (Figure 4.4.4).

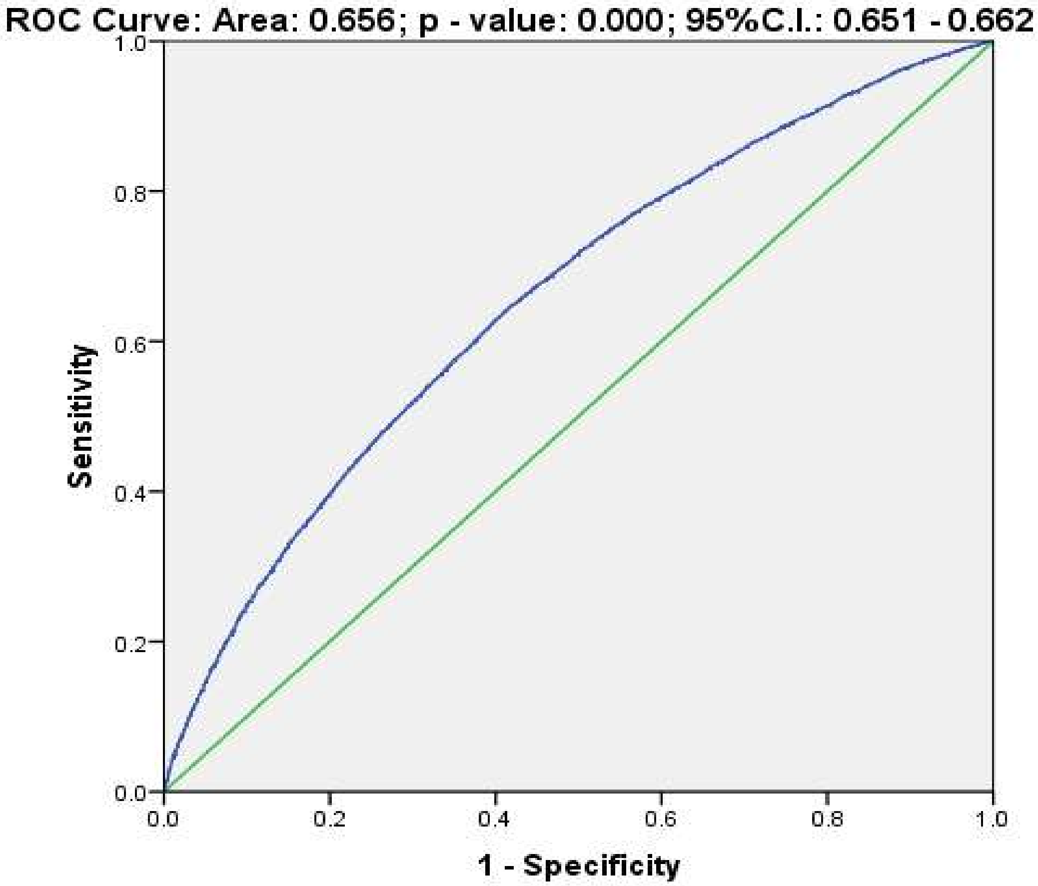


Figure. 4.4.4: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Underweight in the Northern Region of India

Table 4.4.7: - Sensitivity & Specificity of the Model at a different cut of point

Probability (≥)	Sensitivity	Specificity
0.138974	0.970	0.091
0.139484	0.968	0.095
0.148173	0.959	0.116
0.154139	0.949	0.134
0.159906	0.939	0.155
0.166283	0.929	0.173
0.175897	0.909	0.212
0.182100	0.897	0.232
0.185663	0.889	0.247
0.192407	0.878	0.265
0.195699	0.869	0.280
0.200023	0.857	0.301
0.201816	0.848	0.314
0.206563	0.839	0.328
0.212367	0.829	0.345
0.214568	0.817	0.362
0.218148	0.809	0.373
0.223231	0.799	0.389
0.225315	0.788	0.406
0.231347	0.771	0.431
0.233835	0.766	0.438
0.237793	0.758	0.449
0.240480	0.747	0.464
0.243693	0.738	0.474
0.246230	0.729	0.485
0.249390	0.717	0.500
0.253439	0.699	0.519
0.258030	0.687	0.533
0.261891	0.679	0.543
0.272615	0.649	0.580
0.274665	0.638	0.590
0.276874	0.629	0.599
0.280647	**0.613**	**0.613**
0.320863	0.495	0.721
0.323721	0.486	0.730
0.360836	0.381	0.811
0.366481	0.364	0.824
0.432276	0.217	0.915
0.457599	0.167	0.940

4.4.5 Estimation of Child Height

Table 4.4.8 represents the test between subjects' effects, revealing child age, educational level, wealth index, sex of child and BMI have a significant effect on Child Height except type of residence, birth order, and respondent occupation.

Table 4.4.8: Tests of Between Subjects' Effects

Dependent Variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	p-value
Intercept	Hypothesis	764.808	1	764.808	18.9	< 0.001
	Error	8426.81	208.53	40.409a		
Child Age	Hypothesis	1584.183	4	396.046	10.5	< 0.001
	Error	313320.052	8314	37.686b		
Birth Order	Hypothesis	142.021	3	47.34	1.2	0.288
	Error	313320.052	8314	37.686b		
Education Level	Hypothesis	1415.183	3	471.728	12.5	< 0.001
	Error	313320.052	8314	37.686b		
Respondent Occupation	Hypothesis	73.894	2	36.947	0.9	0.375
	Error	313320.052	8314	37.686b		
Type of Residence	Hypothesis	109.916	1	109.916	2.9	0.088
	Error	313320.052	8314	37.686b		
Wealth Index	Hypothesis	1577.212	4	394.303	10.4	< 0.001
	Error	313320.052	8314	37.686b		
BMI	Hypothesis	2394.227	3	798.076	21.2	< 0.001
	Error	313320.052	8314	37.686b		
Child Sex	Hypothesis	2353.481	1	2353.481	62.5	< 0.001
	Error	313320.052	8314	37.686b		
FIT*	Hypothesis	83863.876	1	83863.876	2225.3	< 0.001
	Error	313320.052	8314	37.686b		
Birth Weight	Hypothesis	1402.868	1	1402.868	37.2	< 0.001
	Error	313320.052	8314	37.686b		
a .001 MS (Child Sex) + .999 MS(Error)						
b MS(Error)						

Note: - *Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 55.313 + 1.710\ child\ Age - 0.029\ Child\ Age^2 + 0.000228\ Child\ Age^3$$

Table 4.4.9 represents factors associated with child height in the northern region. Children born in the first birth order (OR: 1.52, 95% CI: 0.95 – 2.41, p = 0.079) have a height that is higher than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.41, 95% CI: 0.89 – 2.24, p = 0.147) have a higher height than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.17, 95% CI: 0.70 – 1.94, p = 0.550) have a height that is higher than children born in the 4 & above birth order.

Children's height is 78% less in mothers with no education (OR: 0.22, 95% CI: 0.13 – 0.38, $p < 0.05$) compared to mothers with higher education. Children's height is 77% less in mothers with primary education (OR: 0.23, 95% CI: 0.13 – 0.41, $p < 0.05$) compared to mothers with higher education. Children's height is 52% less in mothers with secondary education (OR: 0.48, 95% CI: 0.31 – 0.75, $p < 0.05$) compared to mothers with higher education.

Children's height is 2% less in mothers with no occupation (OR: 0.98, 95% CI: 0.62 – 1.55, p = 0.941) compared to agricultural mothers. As compared to agricultural mothers, the height of children is 30% less in mothers with other occupations (OR: 0.70, 95% CI: 0.38 – 1.32, p = 0.271). As compared to rural regions, the height of children is 25% less in urban regions (OR: 0.75, 95% CI: 0.53 – 1.04, p = 0.088).

Children in the poorest group (OR: 0.19, 95% CI: 0.11 – 0.35, $p < 0.05$) have 81% less height than children in the richest group. Children in the poorer group (OR: 0.29, 95% CI: 0.18 – 0.48, $p < 0.05$) have 71% less height than children in the richest group. Children in the middle group (OR: 0.53, 95% CI: 0.34 – 0.81, $p < 0.05$) have 47% less height than children in the richest group. Children in the richer group (OR:

0.82, 95% CI: 0.55 – 1.23, p = 0.338) have 80% less height than children in the richest group.

The height of children with normal BMI (OR: 0.25, 95% CI: 0.13 – 0.48, $p < 0.05$) is 75% less than that of those with obese BMI. The height of children with underweight BMI (OR: 0.11, 95% CI: 0.05 – 0.22, $p < 0.05$) is 89% less than that of children with obese BMI. The height of children with overweight BMI (OR: 0.55, 95% CI: 0.27 – 1.12, p = 0.098) is 45% less than that of children with obese BMI. As compared to female children, the height of male children (OR: 2.91, 95% CI: 2.23 – 3.79, $p < 0.05$) is 2.9 times higher.

Table 4.4.9: Factors Associated with Child Height in the Northern Region

Dependent Variable: Child Height					
Parameter	B	p-value	95% CI		OR (95% CI)
			LL	UL	
Birth Order					
1	0.416	0.079	-0.048	0.88	1.52 (0.95, 2.41)
2	0.342	0.147	-0.121	0.806	1.41 (0.89, 2.24)
3	0.154	0.550	-0.352	0.661	1.17 (0.70, 1.94)
4 & above *(Ref.)*	0				
Education Level					
No Education	-1.516	0.000	-2.055	-0.977	0.22 (0.13, 0.38)
Primary	-1.469	0.000	-2.039	-0.899	0.23 (0.13, 0.41)
Secondary	-0.725	0.001	-1.166	-0.285	0.48 (0.31, 0.75)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	-0.017	0.941	-0.473	0.439	0.98 (0.62, 1.55)
Other	-0.35	0.271	-0.975	0.274	0.70 (0.38, 1.32)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	-0.292	0.088	-0.627	0.043	0.75 (0.53, 1.04)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-1.638	0.000	-2.22	-1.055	0.19 (0.11, 0.35)
Poorer	-1.228	0.000	-1.716	-0.74	0.29 (0.18, 0.48)
Middle	-0.637	0.004	-1.065	-0.209	0.53 (0.34, 0.81)
Richer	-0.199	0.338	-0.606	0.208	0.82 (0.55, 1.23)
Richest *(Ref.)*	0				
BMI					
Normal	-1.39	0.000	-2.046	-0.734	0.25 (0.13, 0.48)
Underweight	-2.251	0.000	-2.964	-1.537	0.11 (0.05, 0.22)
Overweight	-0.602	0.098	-1.315	0.111	0.55 (0.27, 1.12)
Obese *(Ref.)*	0				
Child Sex					
Male	1.067	0.000	0.803	1.332	2.91 (2.23, 3.79)
Female *(Ref.)*	0				
FIT*	1.079	0.000	1.035	1.124	2.94 (2.82, 3.08)
Birth Weight	1.179	0.000	0.800	1.558	3.25 (2.23, 4.75)

**Note: - ***Fit for Child Height with Child Age from CURVEFIT using Cubic Model –

$$Child\ Height = 55.313 + 1.710\ child\ Age - 0.029\ Child\ Age^2 + 0.000228\ Child\ Age^3$$

Table 4.4.10 represents the descriptive statistics of child height by birth order. The mean height of a child in the first and second birth order is around 84.2 cm and 84.2 cm, respectively. The mean height of a child in third and 4 & above birth order is around 83.9 cm and 83.8 cm, respectively.

Table 4.4.10: - Descriptive Statistics of Child Height by Birth Order

Dependent Variable: Child Height				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	84.26	0.18	83.91	84.60
2	84.18	0.18	83.83	84.53
3	83.99	0.21	83.58	84.41
4 & above	83.84	0.23	83.39	84.29

Table 4.4.11 represents a pairwise comparison of child height by birth order. Mean difference of child weight between first and second birth order (M D = 0.07, 95% CI: -0.24 to 0.39, p = 0.646), between first and third birth order (M D = 0.26, 95% CI: -0.15 to 0.67, p = 0.207) and first and 4 & above birth order (M D = 0.42, 95% CI: -0.05 to 0.88, p = 0.079) is statistically insignificant. A mean difference of child height between second and third birth order (M D = 0.19, 95% CI: -0.22 to 0.60, p = 0.369) and second and 4 & above birth order (M D = 0.34, 95% CI: -0.12 to 0.81, p = 0.147) is statistically insignificant. A mean difference of child height between third and 4 & above birth order (M D = 0.15, 95% CI: -0.35 to 0.66, p = 0.550).

Table 4.4.11: - Pairwise Comparison of Child Height by Birth Order

Dependent Variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
1	2	0.07	0.16	0.646	-0.24	0.39
	3	0.26	0.21	0.207	-0.15	0.67
	4 & above	0.42	0.24	0.079	-0.05	0.88
2	3	0.19	0.21	0.369	-0.22	0.60
	4 & above	0.34	0.24	0.147	-0.12	0.81
3	4 & above	0.15	0.26	0.550	-0.35	0.66

Table 4.4.12 represents the descriptive statistics of child height by educational level. The mean height of a child for mothers with no education is around 83.4 cm. For mothers with primary education, the average height of the child is around 83.5 cm. For mothers with secondary education, the average height of the child is around 84.3 cm. Similarly, for mothers with higher education, the average child's height is around 84.9 cm.

Table 4.4.12: - Descriptive Statistics of Child Height by Education Level

Dependent Variable: Child height				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	83.479	0.183	83.121	83.838
Primary	83.526	0.228	83.078	83.974
Secondary	84.270	0.175	83.927	84.613
Higher	84.995	0.245	84.515	85.476

Table 4.4.13 represents a pairwise comparison of child height by educational level. The mean difference in child height between mothers with no education and secondary education (M D = -0.791, 95% CI: -1.17 to -0.42, $p < 0.05$), mothers with no education and higher education level (M D = -1.516, 95% CI: -2.06 to -0.98, $p < 0.05$) is statistically significant. A mean difference in child height between mothers with primary and secondary education (M D = -0.744, 95% CI: -1.17 to -0.31, $p < 0.05$) is statistically significant. A mean difference in child weight between mothers with primary and higher education (M D = -1.469, 95% CI: -2.04 to -0.90, $p < 0.05$) is statistically significant. A mean difference in child weight between mothers with secondary and higher education (M D = -0.725, 95% CI: -1.17 to -0.29, $p < 0.05$) is statistically significant.

Table 4.4.13: - Pairwise Comparison of Child Height by Education Level

Dependent Variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI for Difference	
					Lower Bound	Upper Bound
No education	Primary	-0.047	0.233	0.841	-0.50	0.41
	Secondary	-0.791*	0.191	0.000	-1.17	-0.42
	Higher	-1.516*	0.275	0.000	-2.06	-0.98
Primary	Secondary	-0.744*	0.219	0.001	-1.17	-0.31
	Higher	-1.469*	0.291	0.000	-2.04	-0.90
Secondary	Higher	-0.725*	0.225	0.001	-1.17	-0.29
*Mean difference is significant at the 0.05 level.						

Table 4.4.14 represents the descriptive statistics of child height by respondent occupation. The mean height of the child for mothers with no occupation is around 84.1 cm. But, for mothers with other occupations and agricultural mothers, the average height of the child is around 83.8 cm and 84.2 cm, respectively.

Table 4.4.14: - Descriptive Statistics of Child Height by Respondent Occupation

Dependent Variable: Child Height				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	84.173	0.129	83.92	84.427
Other	83.84	0.248	83.353	84.327
Agriculture	84.19	0.244	83.712	84.669

Table 4.4.15 represents a pairwise comparison of child height by respondent occupation. A mean difference in child height between mothers with no occupation and mothers with other occupations (M D = 0.33, 95% CI: -0.14 to 0.81, p = 0.166) is statistically insignificant. Similarly, the mean difference in child height between mothers with no occupation and mothers doing agriculture (M D = -0.02, 95% CI: -0.47 to 0.44, p = 0.941) is statistically insignificant. The mean difference in child height between mothers with other occupations and mothers doing agriculture (M D = -0.35, 95% CI: -0.98 to 0.27, p = 0.271) is statistically insignificant.

Table 4.4.15: - Pairwise Comparison of Child Height by Respondent Occupation

Dependent Variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
No Occupation	Other	0.33	0.24	0.166	-0.14	0.81
	Agriculture	-0.02	0.23	0.941	-0.47	0.44
Other	Agriculture	-0.35	0.32	0.271	-0.98	0.27

Table 4.4.16 represents the descriptive statistics of Child Height by Type of Residence. The mean height of children in urban as well as rural regions is around 83.9 cm and 84.2 cm, respectively.

Table 4.4.16: - Descriptive Statistics of Child Height by Type of Residence

Dependent Variable: Child Height				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	83.922	0.194	83.542	84.302
Rural	84.214	0.147	83.926	84.502

Table 4.4.17 represents a pairwise comparison of child height by Type of Residence. The mean difference of child height between urban region and rural region (M D = -0.292, 95% CI: - 0.627 to 0.043, p-value = 0.088), is statistically insignificant.

Table 4.4.17: - Pairwise Comparison of Child Height by Type of Residence

Dependent Variable: Child Height						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Urban	Rural	-0.292	0.171	0.088	-0.627	0.043

Table 4.4.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 83 cm. In the poorer and middle groups, children's average height is around 83.5 cm and 84 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 84.6 cm and 84.8 cm, respectively.

Table 4.4.18: - Descriptive Statistics of Child Height by Wealth Index

Dependent Variable: Child Height				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	83.171	0.263	82.655	83.686
Poorer	83.580	0.217	83.155	84.006
Middle	84.171	0.198	83.782	84.559
Richer	84.609	0.199	84.220	84.998
Richest	84.808	0.189	84.437	85.179

Table 4.4.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and middle group (M D = - 1.000, 95% CI: - 1.52 to -0.49, $p < 0.05$), between poorest group and richer group (M D = - 1.439, 95% CI: -1.98 to -0.90, $p < 0.05$), and between poorest group and richest group (M D = - 1.638, 95% CI: -2.22 to – 1.06, $p < 0.05$) is statistically significant. Mean difference of child height between poorer group and middle group (M D = - 0.591, 95% CI: -1.02 to – 0.16, $p < 0.05$), between poorer group and richer group (M D = -1.029, 95% CI: -1.48 to – 0.58, $p < 0.05$), and between poorer group and richest group (M D = - 1.228, 95% CI: - 1.72 to – 0.74, $p < 0.05$) is statistically significantly. A mean difference in child height between the middle group and richer group (M D = - 0.438, 95% CI: - 0.84 to – 0.03, $p < 0.05$), between the middle group and the richest group (M D = - 0.637, 95% CI: - 1.07 to – 0.21, $p < 0.05$) is statistically significant.

Table 4.4.19: - Pairwise Comparison of Child Height by Wealth Index

Dependent Variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Poorest	Poorer	-0.41	0.26	0.114	-0.92	0.10
	Middle	-1.000*	0.26	0.000	-1.52	-0.49
	Richer	-1.439*	0.28	0.000	-1.98	-0.90
	Richest	-1.638*	0.30	0.000	-2.22	-1.06
Poorer	Middle	-0.591*	0.22	0.007	-1.02	-0.16
	Richer	-1.029*	0.23	0.000	-1.48	-0.58
	Richest	-1.228*	0.25	0.000	-1.72	-0.74
Middle	Richer	-0.438*	0.21	0.034	-0.84	-0.03
	Richest	-0.637*	0.22	0.004	-1.07	-0.21
Richer	Richest	-0.199	0.21	0.338	-0.61	0.21
*Mean difference is significant at the 0.05 level.						

Table 4.4.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 85 cm. Similarly, children's average height in females is around 83.5 cm.

Table 4.4.20: - Descriptive Statistics of Child Height by Child Sex

Dependent Variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	84.601	0.162	84.284	84.919
Female	83.534	0.166	83.21	83.859

Table 4.4.21 represents a pairwise comparison of child height by Child Sex. A mean difference of child height between male children and female children (M D = 1.067, 95% CI: 0.80 to 1.33, p-value < 0.05) is statistically significant.

Table 4.4.21: - Pairwise Comparison of Child Height by Child Sex

Dependent Variable: Child Height						
Sex of child	Sex of child	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Male	Female	1.067*	0.13	0.000	0.80	1.33
*Mean difference is significant at the 0.05 level						

Table 4.4.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as an underweight BMI is around 83 cm. The average height of a child with an overweight BMI is around 84.5 cm. Similarly, children's average height in obese BMI is around 85.1 cm.

Table 4.4.22: - Descriptive Statistics of Child Height by BMI

Dependent Variable: Child Height				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	83.738	0.14	83.464	84.012
Underweight	82.878	0.193	82.499	83.257
Overweight	84.526	0.209	84.117	84.936
Obese	85.129	0.34	84.463	85.794

Table 4.4.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.860, 95% CI: 0.51 to 1.21, $p < 0.05$), between normal BMI and overweight BMI (M D = -0.788, 95% CI: - 1.18 to -0.40, $p < 0.05$), and between normal BMI and obese BMI (M D = -1.390, 95% CI: - 2.05 to -0.73, $p < 0.05$) is statistically significant. A mean difference of child height between underweight BMI and overweight BMI (M D = -1.649, 95% CI: - 2.12 to – 1.17, $p < 0.05$) and between underweight BMI and obese BMI (M D = - 2.251 95% CI: - 2.96 to - 1.54, $p < 0.05$) is statistically significant. A mean difference of child height between overweight BMI and underweight BMI (M D = - 1.649, 95% CI: 1.17 to 2.12, $p < 0.05$) is statistically significant.

Table 4.4.23: - Pairwise Comparison of Child Height by BMI

Dependent Variable: Child Height						
BMI	BMI	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Normal	Underweight	0.860*	0.18	0.000	0.51	1.21
	Overweight	-0.788*	0.20	0.000	-1.18	-0.40
	Obese	-1.390*	0.34	0.000	-2.05	-0.73
Underweight	Overweight	-1.649*	0.24	0.000	-2.12	-1.17
	Obese	-2.251*	0.36	0.000	-2.96	-1.54
Overweight	Underweight	1.649*	0.24	0.000	1.17	2.12
	Obese	-0.602	0.36	0.098	-1.32	0.11
*Mean difference is significant at the .05 level.						

4.4.6 Estimation of Child Weight

Table 4.4.24 represents the test between subjects' effects, reveals child age, educational level, place of residence, wealth index, sex of child and BMI is having a significant effect on Child Weight except respondent occupation and birth order.

Table 4.4.24: Tests of Between-Subjects Effects

Dependent Variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	12.947	1	12.947	2.629	0.137
	Error	46.961	9.535	4.925a		
Child Age	Hypothesis	475.436	4	118.859	35.548	< 0.001
	Error	27655.239	8271	3.344b		
Birth Order	Hypothesis	6.642	3	2.214	0.662	0.575
	Error	27655.239	8271	3.344b		
Educational Level	Hypothesis	175.189	3	58.396	17.465	< 0.001
	Error	27655.239	8271	3.344b		
Respondent Occupation	Hypothesis	14.051	2	7.025	2.101	0.122
	Error	27655.239	8271	3.344b		
Place of Residence	Hypothesis	111.302	1	111.302	33.288	< 0.001
	Error	27655.239	8271	3.344b		
Wealth Index	Hypothesis	223.544	4	55.886	16.714	< 0.001
	Error	27655.239	8271	3.344b		
BMI	Hypothesis	955.226	3	318.409	95.228	< 0.001
	Error	27655.239	8271	3.344b		
Sex of Child	Hypothesis	408.204	1	408.204	122.084	< 0.001
	Error	27655.239	8271	3.344b		
FIT	Hypothesis	4214.284	1	4214.284	1260.388	< 0.001
	Error	27655.239	8271	3.344b		
Birth Weight	Hypothesis	229.442	1	229.442	68.621	< 0.001
	Error	27655.239	8271	3.344b		
a .004 MS(B4) + .996 MS(Error)						
b MS(Error)						

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.548\ Child\ Age^{0.338}$$

Table 4.4.25 represents factors associated with child weight in northern region. When compared to children between the ages of 48 and 59 months, children under the age of 12 months (OR: 0.64, 95% CI: 0.43 – 0.98, $p < 0.05$) weigh 36% less. The weight of children between the ages of 12 and 23 months (OR: 0.45, 95% CI: 0.35 – 0.59, $p < 0.05$) is 55% lesser than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.50, 95% CI: 0.42 – 0.60, $p < 0.05$) weigh 50% lesser than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.67, 95% CI: 0.59 – 0.77, $p < 0.005$) weigh 33% less.

Children born in the first birth order (OR: 1.08, 95% CI: 0.94 – 1.24, $p = 0.274$) weigh more than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.03, 95% CI: 0.90 – 1.19, $p = 0.654$) weigh higher than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.01, 95% CI: 0.87 – 1.17, $p = 0.912$) weigh higher than children born in the 4 & above birth order.

Children's weight is 44% less in mothers with no education (OR: 0.56, 95% CI: 0.48 – 0.66, $p < 0.05$) compared to mothers with higher education. Children's weight is 38% less in mothers with primary education (OR: 0.62, 95% CI: 0.52 – 0.73, $p < 0.05$) compared to mothers with higher education. Children's weight is 26% less in mothers with secondary education (OR: 0.74, 95% CI: 0.65 – 0.84, $p < 0.05$) compared to mothers with higher education.

Children's weight is more in mothers with no occupation (OR: 1.14, 95% CI: 1.00 – 1.31, $p = 0.052$) compared to agricultural mothers. As compared to agricultural mothers, the weight of children is high in mothers with other occupations (OR: 1.08, 95% CI: 0.90 – 1.30, $p = 0.423$). As compared to rural region, the weight of children is 25% less in urban region (OR: 0.75, 95% CI: 0.67 – 0.82, $p < 0.05$).

Children in the poorest group (OR: 0.51, 95% CI: 0.43 – 0.61, $p < 0.05$) have 49% less weight than children in the richest group. Children in the poorer group (OR: 0.65, 95% CI: 0.56 – 0.7, $p < 0.05$) have 35% less weight than children in the richest group. Children in the middle group (OR: 0.82, 95% CI: 0.72 – 0.93, $p < 0.05$) have 18% less weight than children in the richest group. Children in the richer group (OR: 0.88, 95% CI: 0.78 – 0.99, $p < 0.05$) have 12% less weight than children in the richest group.

The weight of children with normal women (OR: 0.37, 95% CI: 0.30 – 0.45, $p < 0.05$) is 63% less than that of those with obese women. The weight of children with underweight women (OR: 0.23, 95% CI: 0.19 – 0.29, $p < 0.05$) is 77% lesser than that of children with obese women. The weight of children with overweight women (OR: 0.64, 95% CI: 0.51 – 0.79, $p < 0.05$) is 36% lesser than that of children with obese women. As compared to female children, weight of male children (OR: 1.56, 95% CI: 1.44 – 1.69, $p < 0.05$) is around 2 times higher.

Table 4.4.25: Factors Associated with Child Weight in Northern Region

Dependent Variable: Child Weight					
			95% CI		
Parameter	B	p - value	LL	UL	OR (95% CI)
Child Age (Months)					
< 12	-0.439	0.038	-0.854	-0.024	0.64 (0.43, 0.98)
12 - 23	-0.788	0.000	-1.054	-0.521	0.45 (0.35, 0.59)
24 - 35	-0.691	0.000	-0.878	-0.505	0.50 (0.42, 0.60)
36 - 47	-0.394	0.000	-0.534	-0.255	0.67 (0.59, 0.77)
48 - 59	0				
Birth Order					
1	0.077	0.274	-0.061	0.216	1.08 (0.94, 1.24)
2	0.032	0.654	-0.107	0.17	1.03 (0.90, 1.19)
3	0.009	0.912	-0.143	0.16	1.01 (0.87, 1.17)
4 & above	0				
Education Level					
No Education	-0.576	0.000	-0.736	-0.415	0.56 (0.48, 0.66)
Primary	-0.481	0.000	-0.651	-0.311	0.62 (0.52, 0.73)
Secondary	-0.305	0.000	-0.436	-0.173	0.74 (0.65, 0.84)
Higher	0				
Respondent Occupation					
No Occupation	0.135	0.052	-0.001	0.271	1.14 (1.00, 1.31)
Others	0.076	0.423	-0.11	0.262	1.08 (0.90, 1.30)
Agriculture	0				
Type of Residence					
Urban	-0.294	0.000	-0.395	-0.194	0.75 (0.67, 0.82)
Rural	0				
Wealth Index					
Poorest	-0.672	0.000	-0.846	-0.498	0.51 (0.43, 0.61)
Poorer	-0.428	0.000	-0.574	-0.282	0.65 (0.56, 0.75)
Middle	-0.197	0.003	-0.324	-0.069	0.82 (0.72, 0.93)
Richer	-0.133	0.032	-0.254	-0.011	0.88 (0.78, 0.99)
Richest	0				
BMI					
Normal	-0.995	0.000	-1.191	-0.799	0.37 (0.30, 0.45)
Underweight	-1.459	0.000	-1.672	-1.246	0.23 (0.19, 0.29)
Overweight	-0.451	0.000	-0.664	-0.238	0.64 (0.51, 0.79)
Obese	0				
Child Sex					
Male	0.446	0.000	0.367	0.525	1.56 (1.44, 1.69)
Female	0				
FIT*	1.005	0.000	0.949	1.06	2.73 (2.58, 2.89)
Birth Weight	0.478	0.000	0.365	0.592	1.61 (1.44, 1.81)

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.548\ Child\ Age^{0.338}$$

Table 4.4.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in less than 12 months age group is around 10.9 kg. The mean weight of a child in 12 - 23 months and 24 - 35 months age group is around 10.6 kg. The mean weight of a child in 36 - 47 months age group is around 10.9 kg. The mean weight of a child in 48 - 59 months age group is around 11.3 kg.

Table 4.4.26: Descriptive Statistics of Child Weight by Child Age

Dependent Variable: Child Weight				
Child Age	Mean	Std. Error	95% CI	
			LL	UL
< 12	10.920	0.131	10.664	11.176
12 - 23	10.571	0.069	10.435	10.706
24 - 35	10.667	0.062	10.546	10.788
36 - 47	10.964	0.081	10.806	11.122
48 - 59	11.358	0.105	11.153	11.564

Table 4.4.27 represents a pairwise comparison of child weight by child age. Mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.349, 95% CI: 0.15 to 0.55, p < 0.05) is statistically significant. Mean difference of child weight between < 12 months and 48 - 59 months age group (M D = -0.439, 95% CI: -0.85 to - 0.02, p < 0.05) is statistically significant. Mean difference of child weight between 12 - 23 months and 36 - 47 months age group (M D = - 0.394, 95% CI: -0.61 to - 0.18, p < 0.05), between 12 - 23 months and 48 - 59 months age group (M D = - 0.788, 95% CI: -1.05 to -0.52, p < 0.05) is statistically significant. Mean difference of child weight between 24 - 35 months and 36 - 47 months age group (M D = -0.297, 95% CI: -0.44 to -0.15, p < 0.05), between 24 - 35 months and 48 - 59 months age group (M D = -0.691, 95% CI: -0.88 to -0.51, p < 0.05) is statistically significant. Mean difference of child weight between 36 - 47 months and 48 - 59 months age group (M D = -0.394, 95% CI: -0.53 to -0.26, p < 0.05) is statistically significant.

Table 4.4.27: Pairwise Comparison of Child Weight by Child Age

Dependent Variable: Child Weight						
Child Age	Child Age	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
< 12	12 - 23	0.349*	0.104	0.001	0.15	0.55
	24 - 35	0.253	0.146	0.084	-0.03	0.54
	36 - 47	- 0.045	0.181	0.805	-0.40	0.31
	48 - 59	- 0.439*	0.212	0.038	-0.85	-0.02
12 - 23	24 - 35	- 0.096	0.081	0.234	-0.26	0.06
	36 - 47	- 0.394*	0.108	0.000	-0.61	-0.18
	48 - 59	- 0.788*	0.136	0.000	-1.05	-0.52
24 - 35	36 - 47	- 0.297*	0.074	0.000	-0.44	-0.15
	48 - 59	-0.691*	0.095	0.000	-0.88	-0.51
36 - 47	48 - 59	-0.394*	0.071	0.000	-0.53	-0.26
*Mean difference is significant at the .05 level.						

Table 4.4.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in the first birth order is around 10.9 kg. The mean weight of a child in the second birth order is around 10.8 kg. For third birth order, mean weight of a child is around 10.8 kg. Similarly, for 4 & above birth order, mean weight of a child is around 10.8 kg.

Table 4.4.28: Descriptive Statistics of Child Weight by Birth Order

Dependent Variable: Child Weight				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	10.944	0.053	10.840	11.047
2	10.898	0.053	10.793	11.003
3	10.875	0.063	10.751	10.999
4 & above	10.867	0.069	10.731	11.002

Table 4.4.29 represents a pairwise comparison of child weight by birth order. Mean difference of child weight between first and second birth order (M D = 0.046, 95% CI: -0.048 to 0.140, p = 0.341), between first and third birth order (M D = 0.069, 95% CI: -0.053 to 0.19, p = 0.267) and between first and 4 & above birth order (M D = 0.077, 95% CI: -0.061 to 0.216, p = 0.274) is statistically insignificant. The mean weight difference in children between second and third birth orders (M D = 0.023,

95% CI: -0.099 to 0.146, p = 0.712) as well as between second and 4 & above birth orders (M D = 0.032, 95% CI: -0.107 to 0.170, p = 0.654) is statistically insignificant. The mean weight difference in children between third and 4 & above birth orders (M D = 0.009, 95% CI: -0.143 to 0.16, p = 0.912).

Table 4.4.29: Pairwise Comparisons of Child Weight by Birth Order

Dependent Variable: Child Weight						
(I) Birth Order	(J) Birth Order	Mean Difference (I-J)	Std. Error	p - value	95% CI	
					LL	UL
1	2	0.046	0.048	0.341	-0.048	0.140
	3	0.069	0.062	0.267	-0.053	0.190
	4 & above	0.077	0.071	0.274	-0.061	0.216
2	3	0.023	0.062	0.712	-0.099	0.146
	4 & above	0.032	0.071	0.654	-0.107	0.170
3	4 & above	0.009	0.077	0.912	-0.143	0.160

Table 4.4.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 10.6 kg. For mothers with primary education, average weight of the child is around 10.7 kg. For mothers with secondary education, average weight of the child is around 10.9 kg. Similarly, for mothers with higher education, the average child's weight is around 11.2 kg.

Table 4.4.30: Descriptive Statistics of Child Weight by Educational Level

Dependent Variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	10.661	0.055	10.554	10.768
Primary	10.755	0.068	10.621	10.888
Secondary	10.932	0.052	10.829	11.034
Higher	11.236	0.073	11.093	11.380

Table 4.4.31 represents a pairwise comparison of child weight by educational level. Mean difference of child weight between mothers with no education and primary (M D = -0.094, 95% CI: -0.230 to 0.042, p = 0.175) is statistically insignificant. Mean difference of child weight between mothers with no education and secondary education (M D = -0.271, 95% CI: -0.383 to -0.159, p < 0.05), between mothers with no education and higher education level (M D = -0.576, 95% CI: -0.736 to -0.415, p < 0.05) is statistically significant. Mean difference of child weight between mothers with primary and secondary education (M D = -0.177, 95% CI: -0.305 to -0.049, p < 0.05) and between mothers with primary and higher education (M D = -0.481, 95% CI: -0.651 to -0.311, p < 0.05) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.305, 95% CI: -0.436 to -0.173, p < 0.05) is statistically significant.

Table 4.4.31: Pairwise Comparison of Child Weight by Educational Level

Dependent Variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No education	Primary	-0.094	0.069	0.175	-0.23	0.042
	Secondary	-0.271*	0.057	0.000	-0.383	-0.159
	Higher	-0.576*	0.082	0.000	-0.736	-0.415
Primary	Secondary	-0.177*	0.065	0.007	-0.305	-0.049
	Higher	-0.481*	0.087	0.000	-0.651	-0.311
Secondary	Higher	-0.305*	0.067	0.000	-0.436	-0.173
*Mean difference is significant at the .05 level.						

Table 4.4.32 represents the descriptive statistics of child weight by respondent occupation. Mean weight of the child for mothers with no occupation is around 10.9 kg. But, for mothers with other occupation and agricultural mothers, average weight of the child is around 10.9 kg and 10.8 kg, respectively.

Table 4.4.32: Descriptive Statistics of Child Weight by Respondent Occupation

Dependent Variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	10.961	0.039	10.885	11.036
Other	10.902	0.074	10.757	11.047
Agriculture	10.825	0.073	10.683	10.968

Table 4.4.33 represents a pairwise comparison of child weight by respondent occupation. Mean difference of child weight between mothers with no occupation and mother with other occupation (M D = 0.059, 95% CI: -0.081 to 0.2000, p = 0.410), between mothers with no occupation and agricultural mothers (M D = 0.135, 95% CI: -0.001 to 0.271, p = 0.052) is statistically insignificant. Similarly, mean difference of child weight between mothers' other occupation and agricultural mothers (M D = 0.076, 95% CI: -0.110 to 0.262, p = 0.423) is statistically insignificant.

Table 4.4.33: Pairwise Comparison of Child Weight by Respondent Occupation

Dependent Variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No Occupation	Other	0.059	0.072	0.41	-0.081	0.200
	Agriculture	0.135	0.069	0.052	-0.001	0.271
Other	Agriculture	0.076	0.095	0.423	-0.110	0.262

Table 4.4.34 represents the descriptive statistics of child weight by type of residence. Mean weight of child in urban is around 10.7 kg and mean weight of child in rural is around 11 kg.

Table 4.4.34: Descriptive Statistics of Child Weight by Type of Residence

Dependent Variable: Child Weight				
Type of residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	10.749	0.058	10.635	10.862
Rural	11.043	0.044	10.957	11.129

Table 4.4.35 represents a pairwise comparison of child weight by type of residence. Mean difference of child weight between urban and rural region (M D = 0.294, 95% CI: 0.194 to 0.395, $p < 0.05$) is statistically significant.

Table 4.4.35: Pairwise Comparisons of Child Weight by Type of Residence

Dependent Variable: Child Weight						
Type Of Residence	Type Of Residence	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Rural	Urban	0.294*	0.051	0.000	0.194	0.395
*Mean difference is significant at the .05 level.						

Table 4.4.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.5 kg. In the poorer groups, children's average weight is around 10.7 kg. In the middle groups, children's average weight is around 10.9 kg. Similarly, in richer as well as richest groups, the average weight of children is around 11 kg.

Table 4.4.36: Descriptive Statistics of Child Weight by Wealth Index

Dependent Variable: Child Weight				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.510	0.079	10.356	10.664
Poorer	10.754	0.065	10.627	10.881
Middle	10.985	0.059	10.869	11.101
Richer	11.049	0.059	10.933	11.165
Richest	11.182	0.056	11.071	11.292

Table 4.4.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest and poorer group (M D = - 0.244, 95% CI: -0.396 to - 0.092, $p < 0.05$), between poorest group and middle group (M D = - 0.475, 95% CI: -0.629 to - 0.321, $p < 0.05$), between poorest group and richer group (M D = - 0.539, 95% CI: -0.701 to - 0.377, $p < 0.05$), and between poorest group and richest group (M D = - 0.672, 95% CI: -0.846 to - 0.498, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and middle group (M D = - 0.231, 95% CI: -0.359 to – 0.103, $p < 0.05$), between poorer group and richer group (M D = -0.295, 95% CI: -0.430 to – 0.160, $p < 0.05$), and between poorer group and richest group (M D = - 0.428, 95% CI: -0.574 to – 0.282, $p < 0.05$) is statistically significantly. Mean difference of child weight between middle and richest group (M D = - 0.197, 95% CI: -0.324 to – 0.069, $p < 0.05$) is statistically significant. Mean difference of child weight between richer and richest group (M D = - 0.133, 95% CI: -0.254 to – 0.011, $p < 0.05$) is statistically significant.

Table 4.4.37: Pairwise Comparisons of Child Weight by Wealth Index

Dependent Variable: Child Weight						
Wealth Index	Wealth index	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Poorest	Poorer	- 0.244*	0.077	0.002	-0.396	-0.092
	Middle	- 0.475*	0.078	0.000	-0.629	-0.321
	Richer	- 0.539*	0.083	0.000	-0.701	-0.377
	Richest	- 0.672*	0.089	0.000	-0.846	-0.498
Poorer	Middle	- 0.231*	0.065	0.000	-0.359	-0.103
	Richer	- 0.295*	0.069	0.000	-0.43	-0.16
	Richest	- 0.428*	0.074	0.000	-0.574	-0.282
Middle	Richer	-0.064	0.062	0.300	-0.185	0.057
	Richest	- 0.197*	0.065	0.003	-0.324	-0.069
Richer	Richest	- 0.133*	0.062	0.032	-0.254	-0.011
*Mean difference is significant at the 0.05 level.						

Table 4.4.38 represents the descriptive statistics of child weight by BMI. The average weight of a child with a normal woman is around 10.6 kg. The average weight of a child in underweight woman is around 10 kg. The average weight of a child in an overweight woman is around 11 kg. Similarly, children's average weight in obese woman is around 11.6 kg.

Table 4.4.38: Descriptive Statistics of Child Weight by BMI

Dependent Variable: Child Weight				
			95% CI	
BMI	Mean	Std. Error	LL	UL
Normal	10.627	0.042	10.546	10.709
Underweight	10.164	0.058	10.051	10.276
Overweight	11.171	0.062	11.049	11.293
Obese	11.622	0.101	11.424	11.821

Table 4.4.39 represents a pairwise comparison of child weight by BMI. Mean difference of child weight between normal and underweight women (M D = 0.464, 95% CI: 0.358 to 0.569, $p < 0.05$), between normal women and overweight women (M D = - 0.544, 95% CI: -0.659 to - 0.428, $p < 0.05$) is statistically significant. Also, mean difference of child weight between normal BMI and obese BMI (M D = - 0.995, 95% CI: -1.191 to - 0.799, $p < 0.05$) is statistically significant. Mean difference of child weight between underweight women and overweight women (M D = - 1.008, 95% CI: -1.149 to - 0.866, $p < 0.05$) and between underweight woman and obese woman (M D = - 1.459, 95% CI: -1.672 to - 1.246, $p < 0.05$) is statistically significant. Mean difference of child weight between overweight woman and obese woman (M D = - 0.451, 95% CI: -0.664 to - 0.238, $p < 0.05$) is statistically significant.

Table 4.4.39: Pairwise Comparisons of Child Weight by BMI

Dependent Variable: Child Weight						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Normal	Underweight	0.464*	0.054	0.000	0.358	0.569
	Overweight	-0.544*	0.059	0.000	-0.659	-0.428
	Obese	-0.995*	0.100	0.000	-1.191	-0.799
Underweight	Overweight	-1.008*	0.072	0.000	-1.149	-0.866
	Obese	-1.459*	0.109	0.000	-1.672	-1.246
Overweight	Obese	-0.451*	0.108	0.000	-0.664	-0.238
*Mean difference is significant at the 0.05 level.						

Table 4.4.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 11.1 kg. Similarly, children's average weight in females is around 10.6 kg.

Table 4.4.40: Descriptive Statistics of Child Weight by Child Sex

Dependent Variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	11.119	0.048	11.024	11.213
Female	10.673	0.049	10.576	10.77

Table 4.4.41 represents a pairwise comparison of child weight by Child Sex. Mean difference of child weight between in male and female children (M D = 0.446, 95% CI: 0.367 to 0.525, $p < 0.05$) is statistically significant.

Table 4.4.41: Pairwise Comparisons of Child Weight by Child Sex

Dependent Variable: Child Weight						
Sex of child	Sex of child	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Male	Female	0.446*	0.04	0.000	0.367	0.525
* Mean difference is significant at the 0.05 level.						

4.4.7 Growth Nomogram

Table 4.4.42: Birth-weight categories of under-5 Children by their socio-demographic characteristic

Socio-demographic Characteristics		Birthweight (gm)								
		< 2000		2000 - 2499		2500 - 2999		3000+		Total
		n_1	%	n_2	%	n_3	%	n_4	%	n
Child Age	< 12	258	3.9	903	13.8	1988	30.3	3409	52	6558
	12 - 23	241	4.2	727	12.6	1778	30.8	3020	52.4	5766
	24 - 35	255	4	839	13.2	1874	29.5	3382	53.3	6350
	36 - 47	249	3.9	762	11.9	1769	27.7	3608	56.5	6389
	48 - 59	212	3.4	699	11.3	1647	26.6	3627	58.6	6186
		Chi-square (d.f. = 12) = 89.687, p < 0.001								
Sex of Child	Boys	673	3.8	2174	12.4	4907	27.9	9823	55.9	17577
	Girls	709	4.6	1984	12.9	4412	28.8	8226	53.7	15331
		Chi-square (d.f. = 3) = 24.038, p < 0.001								
Birth Order	1	686	5.3	1626	12.6	4003	31.1	6573	51	12889
	2	369	3.5	1408	13.2	3091	29	5777	54.3	10644
	3	182	3.6	627	12.4	1321	26	2945	58	5075
	4 & above	145	3.4	497	11.6	904	21	2755	64.1	4300
		Chi-square (d.f. = 9) = 308.893, p < 0.001								
BMI	< 18.5	360	5.5	877	13.5	1864	28.7	3395	52.3	6495
	18.5 -24.9	815	4	2581	12.7	5701	28	11298	55.4	20395
	25.0 - 29.9	143	3.5	481	11.6	1222	29.5	2294	55.4	4141
	>= 30	44	3.9	125	11	310	27.3	656	57.8	1136
		Chi-square (d.f. = 9) = 59.717, p < 0.001								
Highest Educational Level	No education	360	3.6	1142	11.3	2361	23.5	6202	61.6	10065
	Primary	245	5.1	711	14.9	1298	27.2	2521	52.8	4774
	Secondary	635	4.6	1836	13.3	4262	30.9	7081	51.3	13814
	Higher	141	3.3	470	11.1	1398	32.9	2244	52.8	4254
		Chi-square (d.f. = 9) = 350.097, p < 0.001								
Respondent Occupation	No Occupation	178	3.8	551	11.9	1344	29.1	2549	55.2	4622
	Others	29	6.2	44	9.3	116	24.6	283	59.9	473
	Agriculture	28	4.9	64	11.1	138	24.1	343	59.9	573
	Don't Know	0	0	2	8.5	9	40.6	12	50.8	23
		Chi - square (d.f. = 9) = 21.392, p = 0.011								
Type of Residence	Urban	455	4.1	1566	14.1	3331	29.9	5777	51.9	11129
	Rural	926	4.3	2593	11.9	5988	27.5	12272	56.3	21779
		Chi - square (d.f. = 3) = 69.688, p < 0.001								
Wealth Index	Poorest	138	3.8	381	10.6	757	21	2333	64.6	3610
	Poorer	221	4.1	623	11.5	1357	25.1	3203	59.3	5404
	Middle	314	4.7	947	14.1	1726	25.7	3724	55.5	6711
	Richer	394	5.3	943	12.8	2268	30.7	3775	51.1	7381
	Richest	314	3.2	1264	12.9	3210	32.7	5015	51.2	9803
		Chi - square (d.f. = 12) = 393.866, p < 0.001								

Birth-weight by Socio-demographic characteristics

Table 4.4.42 shows the distribution of under-5 children by their birth weight and sociodemographic characteristics in the Northern Region of India. Distribution of under-5 children by their age & birth weight showed that 3.4% - 4.2% children had their birth – weight below 2000 gm; 11.3% - 13.8% children had their birth – weight between 2000 and 2499 gm; 26.6% - 30.8% children had their birth – weight between 2500 – 2999 gm and 52% - 58.6% children had their birth – weight in 3000 gm and above. A significant association ($\chi^2_{df=12} = 89.687,\ p < 0.001$) was observed between the age of the children and their birth – weight. Also, more boys (55.9%) had their birth – weight of 3000 gm & above, than girls (53.7%). Similarly, more girls had their birth – weight less than 3000 gm than boys. Like age, sex was also found to be significantly associated ($\chi^2_{df=3} = 24.038,\ p < 0.001$) with the birth – weight of the under-5 children.

Considering birth order, more children with higher birth order had a birthweight of 3000 gm & above, and consequently, less number of children with higher birth – order had a birth – weight less than 3000 gm. Birth order was found to have a significant relationship ($\chi^2_{df=9} = 308.893,\ p < 0.001$) with birth weight in children under the age of five, along with age and sex. For Body Mass Index (BMI), 3.5% - 5.5% of under – 5 children with different BMI scores had their birth – weight less than 2000 gm; 11% -13.5% of the children had their birth – weight between 2000 gm and 2499 gm; 27.3% - 29.5% of the children had their birth – weight between 2500 gm and 2999 gm. In these birth–weight categories, the percentage of children decreased as the BMI score increased. Almost 52.3% - 57.8% of the children belong to the birth–weight category of 3000 gm & above. Additionally, as BMI scores increased, the percentage of children increased as well. BMI was also found to be significantly correlated ($\chi^2_{df=9} = 59.717,\ p < 0.001$) with a birth weight of children under 5 years of age.

Considering the highest education level of the mother, 3.3% - 5.1% of the under-5 children had their birth – weight below 2000 gm; 11.1% - 14.9% of the children had their birth – weight ranging from 2000 gm to 2499 gm; 23.5% - 32.9% of children had their birth – weight between 2500 – 2999 gm and 51.3% - 61.6% of children had their birth – weight of 3000 gm & above. The highest education level of the mother and the birth weight of the child is significantly correlated ($\chi^2_{df=9} = 350.097,\ p < 0.001$). Furthermore, when the occupation of the mother was considered with a birth – weight of under 5 children, our analysis showed that there is a significant association ($\chi^2_{df=9} = 21.392, d.f. = 9, p = 0.011$) between the mother's occupation and birth – weight of under-5 children.

The analysis further tells that the other two factors of the respondent – type of place of residence as well as wealth index also played an important role in the determination of their birth – weight. Findings showed that 4.1% of urban and 4.3% of rural under-5 children had their birth – weight below 2000 gm. For birth–weight groups 2000 – 2499 gm as well as 2500 – 2999 gm, the percentage of under – 5 children were more in urban areas than in rural areas. However, for the birth–weight group 3000 gm & above, the situation was just the reverse. The type of place of children was significantly associated ($\chi^2_{df=3} = 69.688,\ p < 0.001$) with their birth – weight. For the wealth index, our analysis revealed almost similar trends. The percentage of under-5 children in various wealth index categories increased with an increase in their wealth index for all birth–weight categories below 3000 gm. However, this trend was reversed for the birth-weight category 3000 gm & above, i.e., the percentage of children in various wealth index categories decreased with an increase in their wealth index. The wealth index of children under the age of five and their birth weight were found to be significantly correlated ($\chi^2_{df=12} = 393.866, p < 0.001$).

4.4.7.1 Growth Estimation of Under-5 Children using Statistical Model

In order to estimate the growth curves, all 11 statistical models were fitted to the height and weight data of children under the age of five from the Northern Region of India, taking into account their ages (in months) for each of the four birth-weight groups independently. By applying the best-fit criterion to the models, our analysis reveals that only the *Cubic Model* and the *Power Model*, provided the best fit to the height and weight data of under-5-year-olds who fell into different birth-weight categories, allowing us to estimate the growth of boys and girls separately. The findings of only 2 best-fit models are displayed here (*Tables 2 & 3*).

Table 4.4.43 describes the model summary for the height of boys & girls by their birth-weight categories for Northern India. For the height of boys as well as girls, a best-fitted model was a *cubic model*. For the height of the boys, considering the Coefficient of Determination (R^2), this model fitted best for the birth-weight group less than 2000 gm ($R^2 = 0.832$), followed by the group 2500 – 2999 gm ($R^2 = 0.818$), group 2000 – 2499 gm ($R^2 = 0.797$) and birth-weight group 3000 gm & above ($R^2 = 0.781$). Similarly, for the height of girls, the cubic model fitted best for the birth-weight group 2500 – 2999 gm ($R^2 = 0.818$), followed by groups 2000 – 2499 ($R^2 = 0.804$), a group less than 2000 gm ($R^2 = 0.794$) and the birth-weight group 3000 gm and above ($R^2 = 0.777$).

Table 4.4.43: Model's summary for Height of Boys & Girls by their Birthweight categories (North Region): NFHS - 4 (2015-16)

Birthweight	Model	R^2	Constant	d.f.		f	b_1	b_2	b_3
				Regression	Residuals				
Boys									
< 2000	Cubic	0.832	52.829	3	770	1271.6	1.922	-0.036	0.0003
2000 - 2499	Cubic	0.797	55.320	3	3636	3456.6	1.734	-0.030	0.0002
2500 - 2999	Cubic	0.818	55.775	3	6373	9522.3	1.698	-0.029	0.0002
3000 +	Cubic	0.781	560682	3	13730	16347.8	1.676	-0.028	0.0002
Girls									
< 2000	Cubic	0.794	53.202	3	777	996.3	1.723	-0.029	0.0002
2000 - 2499	Cubic	0.804	54.995	3	2521	3453.5	1.533	-0.022	0.0001
2500 - 2999	Cubic	0.818	54.937	3	4082	6130.3	1.589	-0.023	0.0001
3000 +	Cubic	0.777	56.020	3	11764	13660.9	1.571	-0.024	0.0001

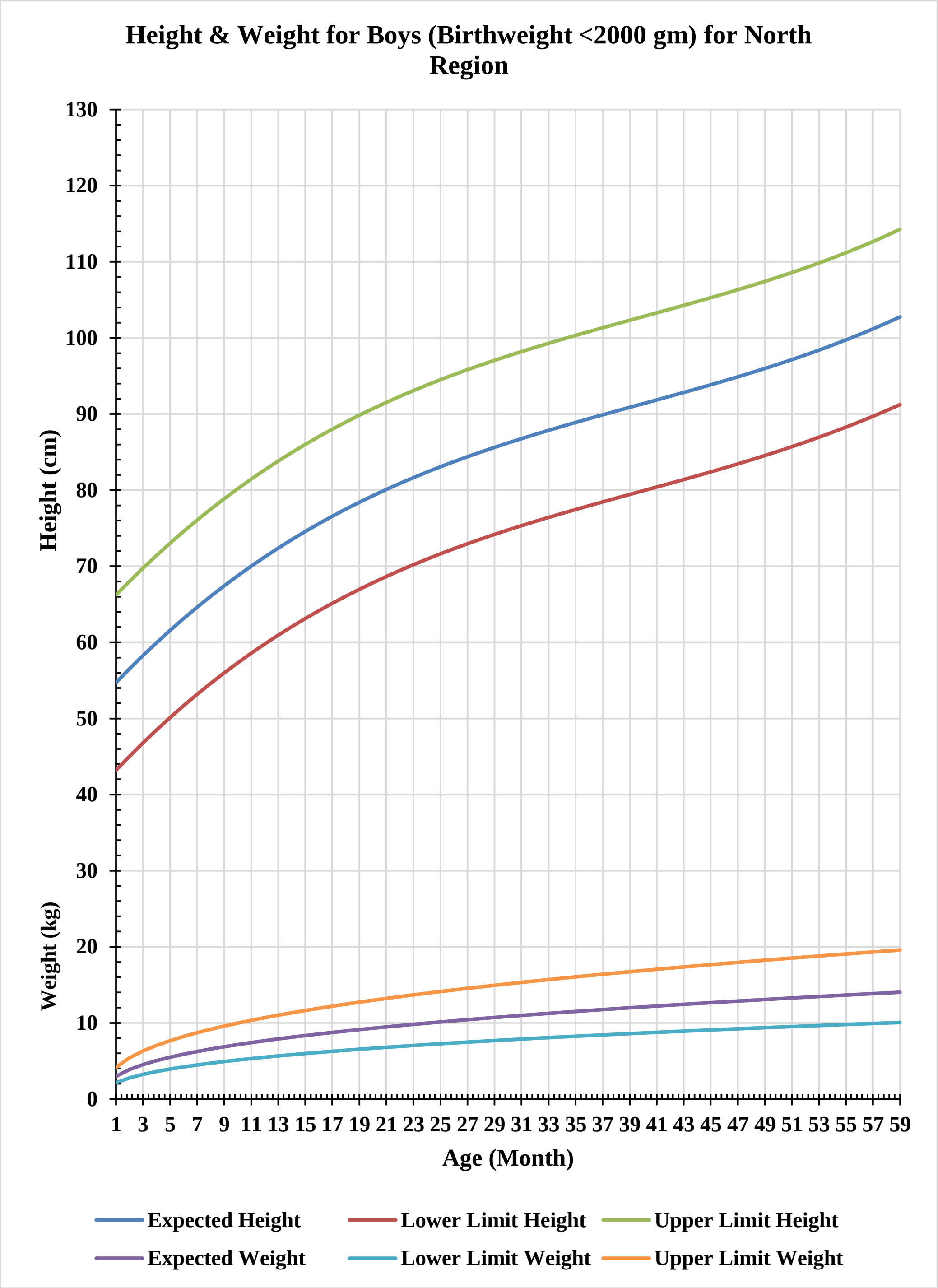
Table 4.4.44 describes the model summary for the weight of boys & girls by their birthweight categories for Northern India. For weight of the boys as well as girls, best - fitted model was *power model.* Further, considering boys, as per Coefficient of Determination (R^2), this model fitted best for birth-weight group less than 2000 gm ($R^2 = 0.8000$), followed by birth-weight group ($R^2 0.774$), group 2500 – 2999 gm ($R^2 = 0.771$) and birth-weight group 3000 gm & above ($R^2 - 0.719$). Similarly, for estimating the weight of the girls, *Power Model* fitted best for the best-weight group 2500 – 2999 gm ($R^2 = 0.785$), followed by group 2000 – 2499 gm ($R^2 = 0.784$), a group less than 2000 gm ($R^2 = 0.743$) and the birth-weight group 3000 gm & above ($R^2 = 0.733$).

Table 4.4.44: Model's summary for Weight of Boys & Girls by Birthweight categories (North Region): NFHS - 4 (2015-16)

Birthweight	Model	R^2	Constant	d.f.		f	b_1
Boys				**Regression**	**Residuals**		
< 2000	Power	0.800	2978.313	1	774	3097.2	0.380
2000 - 2499	Power	0.774	3455.282	1	2643	9032.3	0.345
2500 - 2999	Power	0.771	3618.851	1	6379	21498.2	0.337
3000 +	Power	0.719	3845.178	1	13750	35140.0	0.323
Girls							
< 2000	Power	0.743	2915.670	1	779	2255.0	0.368
2000 - 2499	Power	0.784	3220.047	1	2525	9173.5	0.354
2500 - 2999	Power	0.785	3325.542	1	5901	21552.5	0.351
3000 +	Power	0.733	3519.221	1	11787	32313.7	0.337

4.4.7.2 Height & Weight Curves for boys & girls for the Northern Region

We estimated growth values – considering mean height and mean weight of under-5 children for their ages – ranging from 1 to 59 months, considering all four birth-weight categories $(< 2000\ gm, 2000 - 2499\ gm, 2500 - 2999\ gm\ and\ 3000\ gm\ \&\ above)$ by using *Cubic Model* or *Power Model* whichever fitted best under the situation, for boys as well as girls, separately. So, for each of the birth weight groups and the two sexes separately, growth charts were produced using mean height and mean weight curves. Fig 4.4.5 (a) to Fig 4.4.5 (d) shows estimated mean height and mean weight curves for boys for each of the birth-weight group separately. Similarly, estimated mean height and mean weight curves for girls for all four birth-weight categories are shown in Fig 4.4.6 (a) to Fig 4.4.6 (d). In addition to providing curves for the estimated mean height and mean weight in each case, the graphs provided here also provide curves for the 95% upper and lower confidence bounds. As a result, it is possible to determine not only the expected growth values of under-5 children in terms of their mean height and mean weight for their ages (months) in each case, but also their 95% upper and lower confidence limits. These curves are provided in Figures 4.4.5 (a) through Figure 4.4.5 (d) and Figures 4.4.6 (a) through Figure 4.4.6 (d).



$Figure\ 4.4.5(a)$: NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Boys of North Region (India), Using Cubic and Power Model, respectively

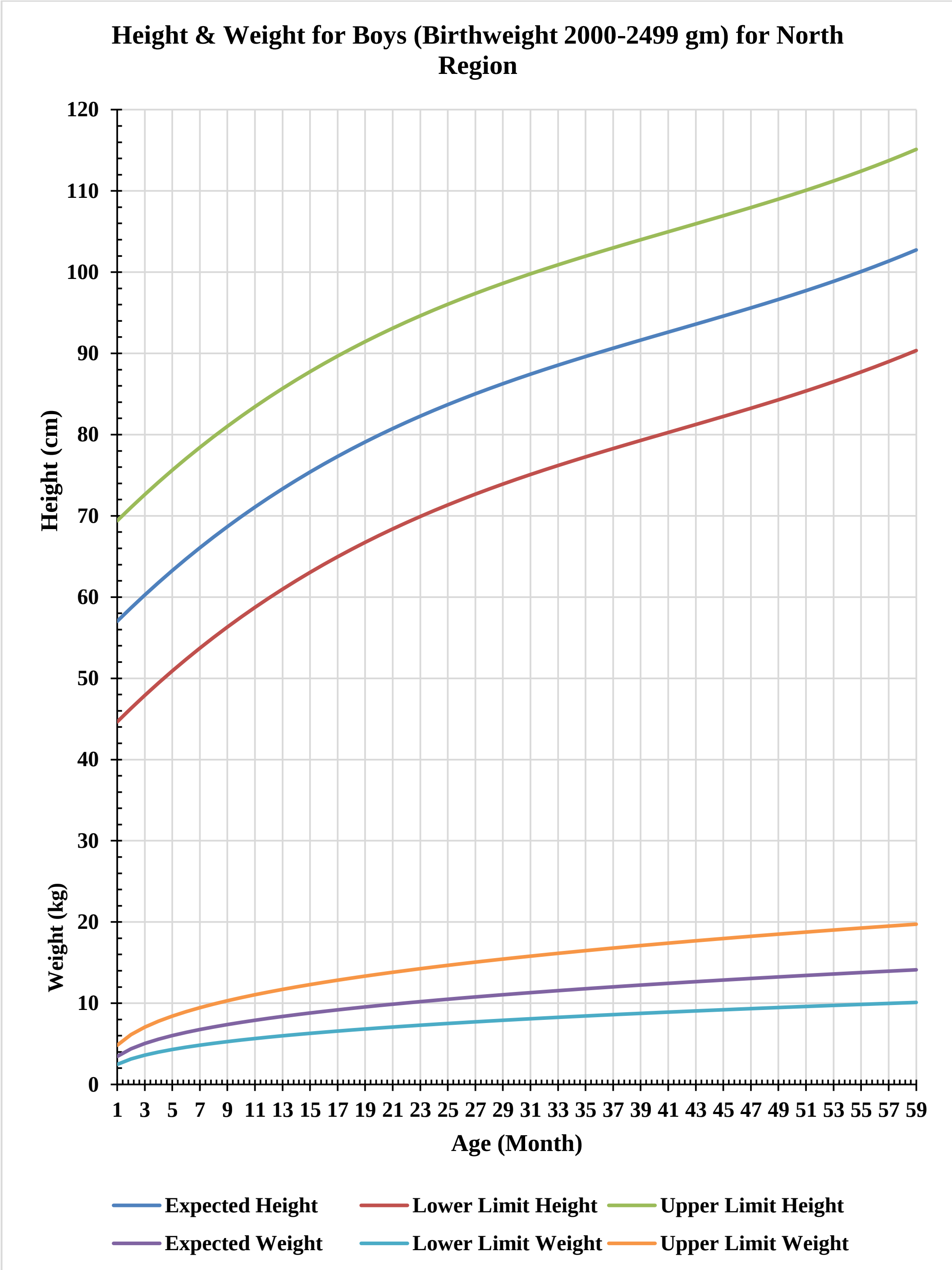


Figure 4.4.5(*b*): NFHS-4 (Birth-weight 2000-2499 gm): Estimated Height & Weight Curves for Boys of North Region (India), Using Cubic and Power Model, respectively

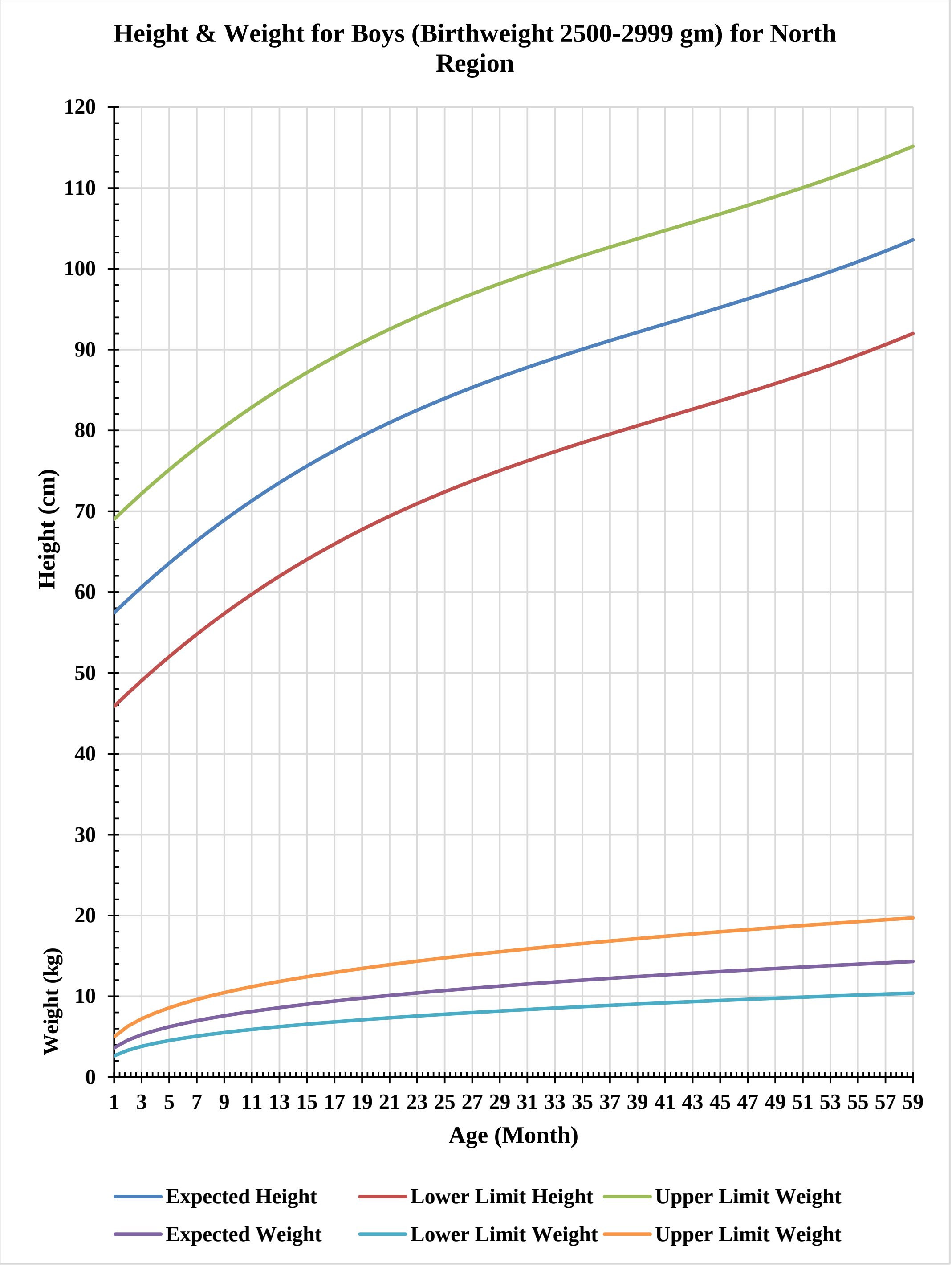


Figure 4.4.5(*c*): NFHS-4 (Birth-weight 2500-2999 gm): Estimated Height & Weight Curves for Boys of North Region (India), Using Cubic and Power Model, respectively

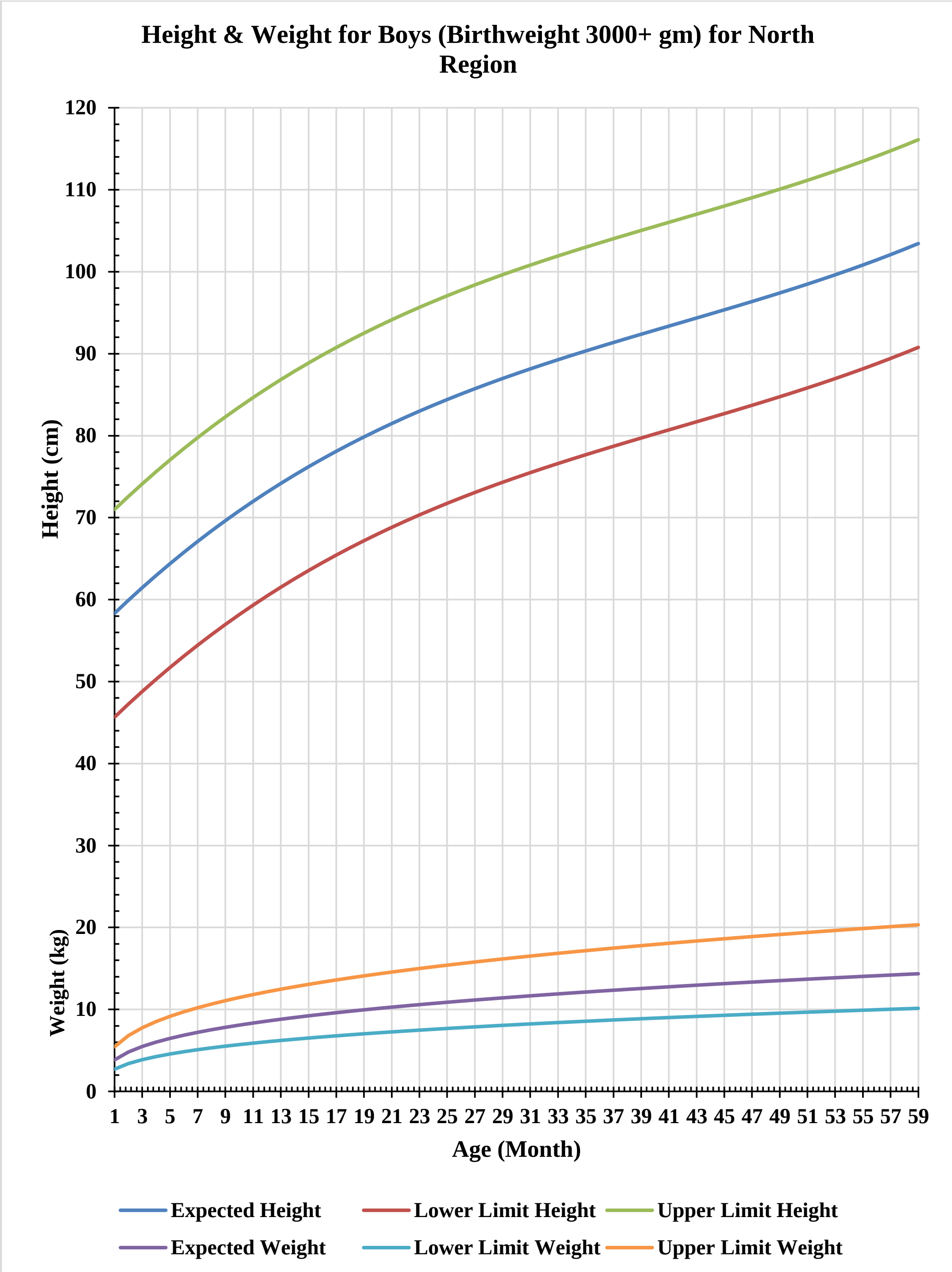


Figure 4.4.5(*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Boys of North Region (India), Using Cubic and Power Model, respectively

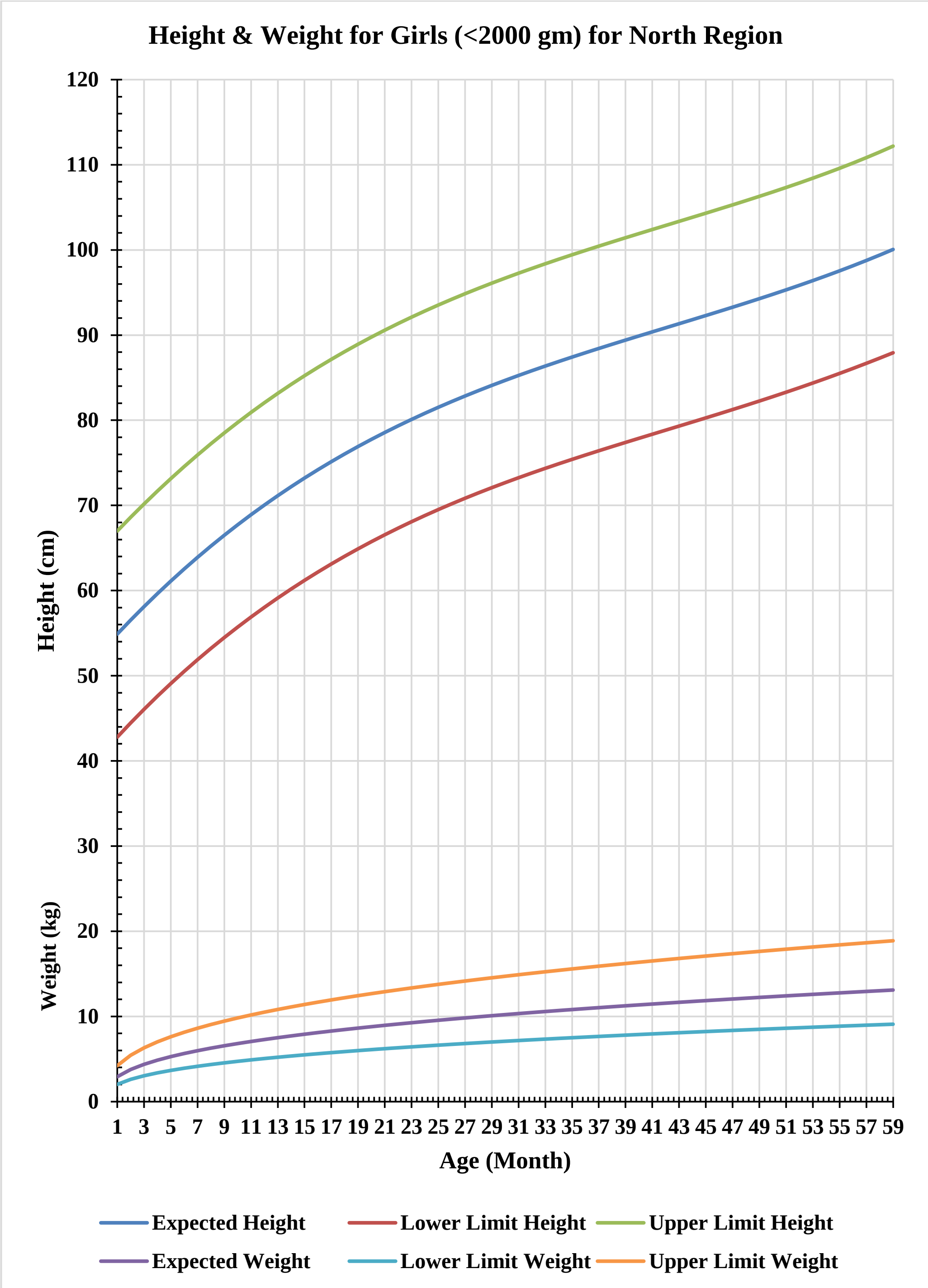
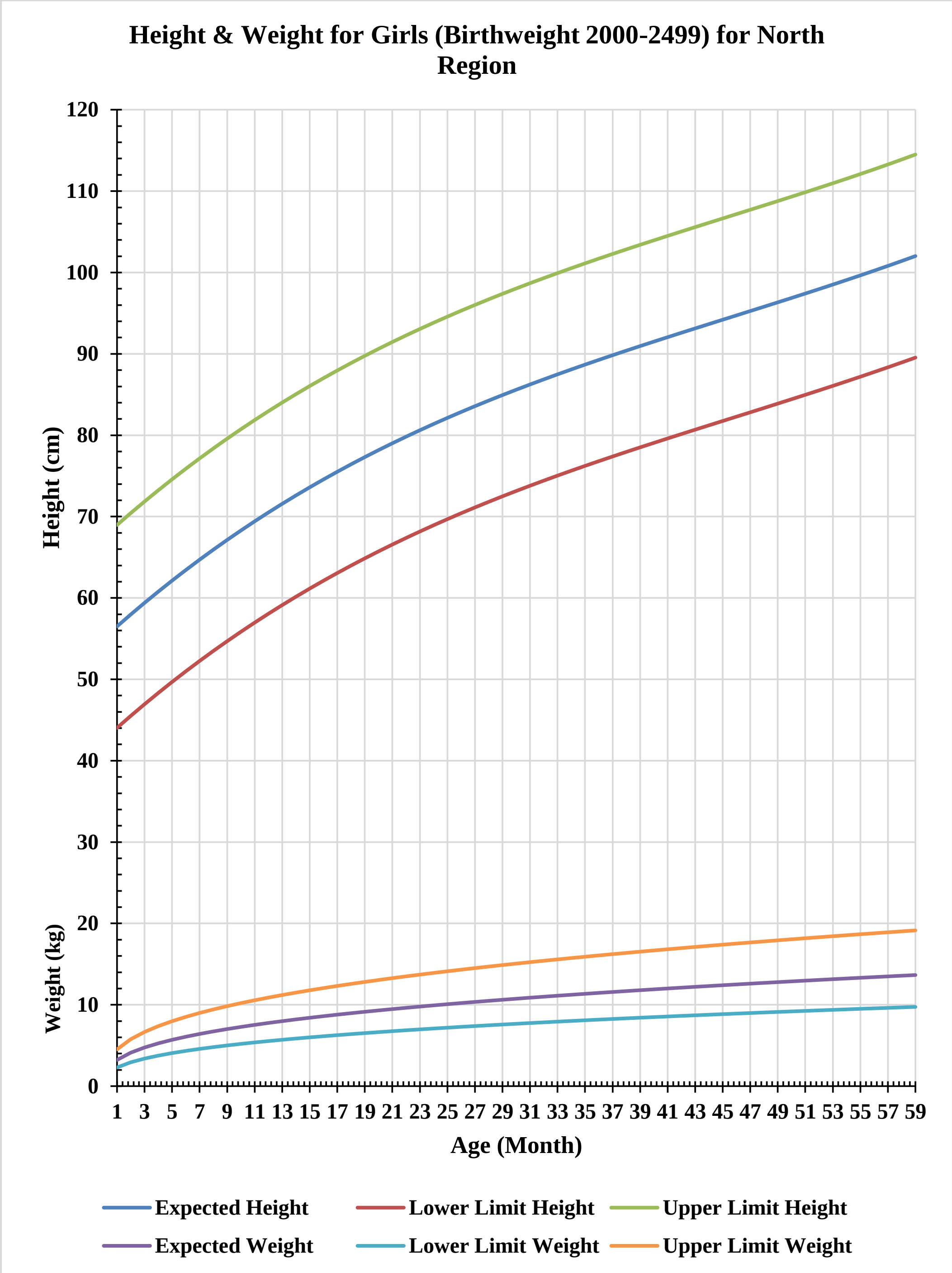


Figure 4.4.6(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Girls of North Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.4.6(b): NFHS-4 (Birth-weight 2000-2499 gm): Estimated Height & Weight Curves for Girls of North Region (India), Using Cubic and Power Model, respectively

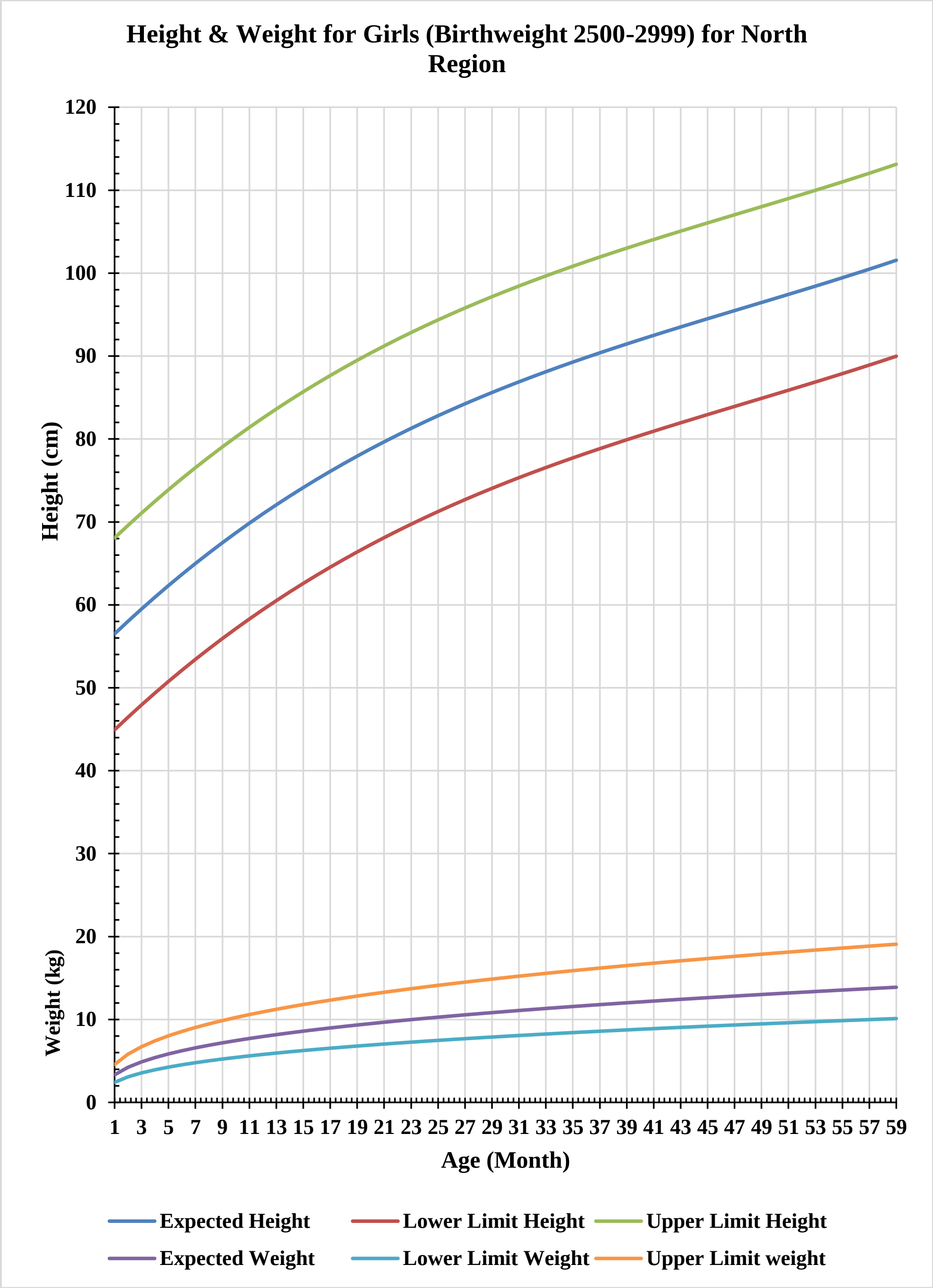
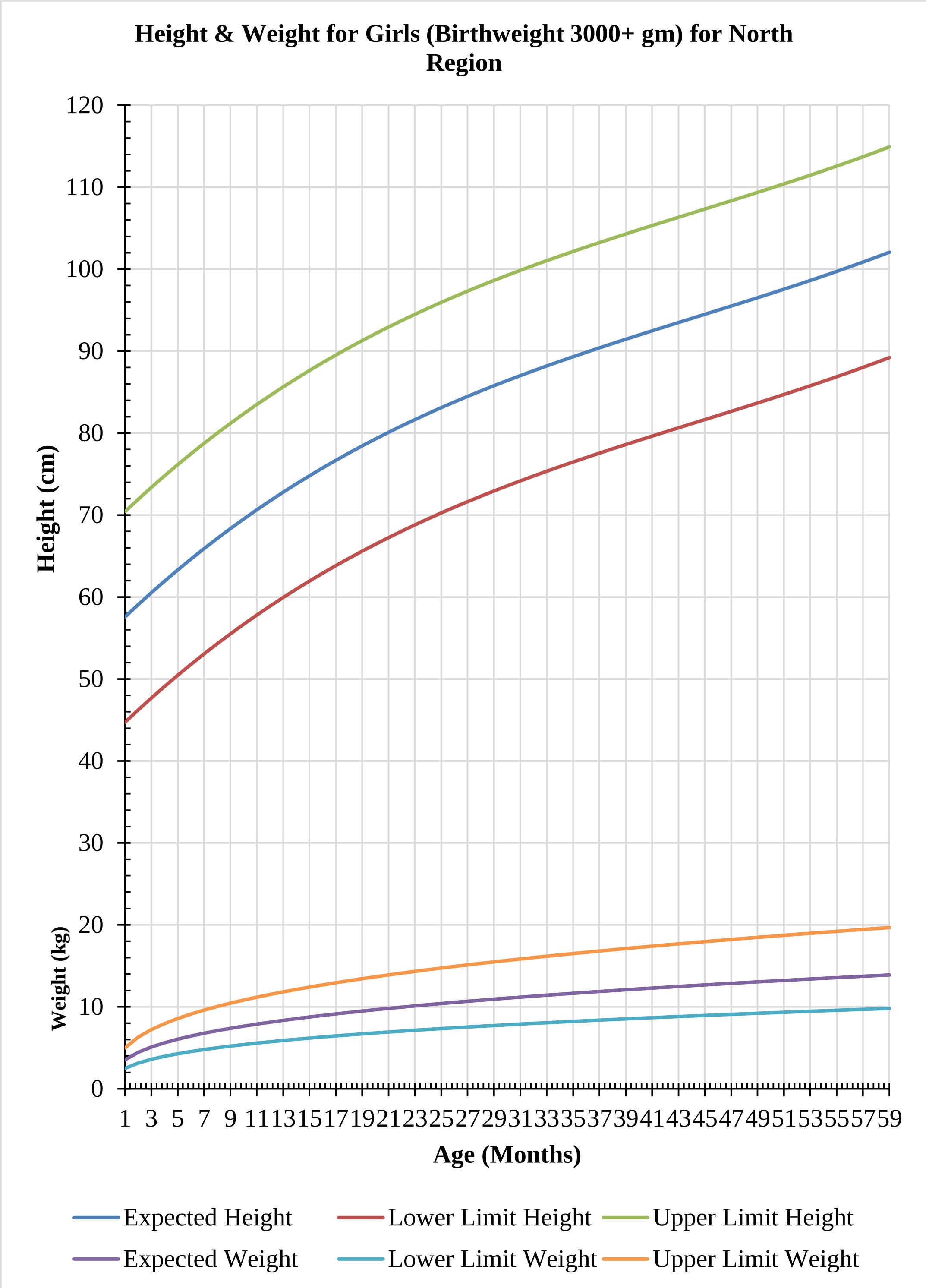


Figure 4.4.6(*c*): NFHS-4 (Birth-weight 2500-2999 gm): Estimated Height & Weight Curves for Girls of North Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.4.6(d): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Girls of North Region (India), Using Cubic and Power Model, respectively

4.5 Southern Region

This Region consists of 5 States & 3 UTs, namely – Andaman & Nicobar Island, Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Puducherry, Tamil Nadu, and Telangana.

4.5.1 Status of Under-Nutrition

Table 4.5.1: Prevalence rates (%) of stunting, wasting, and underweight.

	Stunting	Wasting	Underweight
Southern Region	**25.9**	**17.4**	**24.2**
Andaman & Nicobar Islands	23.3	18.9	21.5
Andhra Pradesh	31.4	17.2	31.9
Karnataka	36.2	26.1	35.2
Kerala	19.7	15.7	16.1
Lakshadweep	26.8	13.7	23.6
Puducherry	23.7	23.6	22.0
Tamil Nadu	27.1	19.7	23.8
Telangana	28.0	18.0	28.3

Figure 4.5.1: Prevalence rates (%) of stunting, wasting, and underweight.

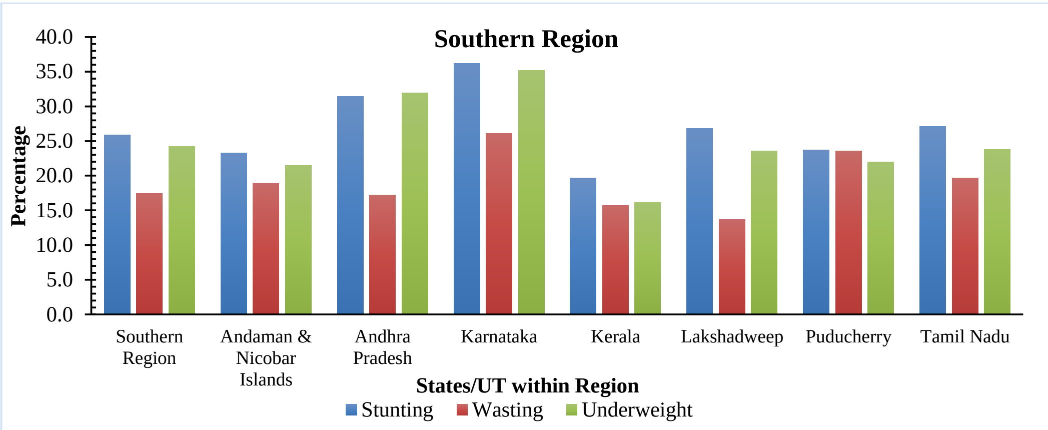


Table 4.5.1 and Figure 4.5.1 illustrate the prevalence rates of stunting, wasting, and underweight in the Southern Region. Stunting ranges from 36.2% in Karnataka to 19.7% in Kerala. The highest rate of wasting (26.1%) is observed in Karnataka, while the lowest (13.7%) is in Lakshadweep. In terms of underweight prevalence, Karnataka reports the highest rate at 35.2%, whereas Kerala has the lowest at 16.1%.

4.5.2 Stunting

Table 4.5.2: - Odds Ratio of Stunting in Under-5 Children by socio-demographic variables in the Southern Region of India

Socio-demographic Variables	p - values	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.36	2.13	2.61
24 - 35	0.000	1.93	1.75	2.13
36 - 47	0.000	1.94	1.76	2.14
48 - 59	0.000	1.58	1.42	1.75
Child Sex				
Female *(Ref)*		1.00		
Male	0.004	1.09	1.03	1.16
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.21	1.88	2.62
Poorer	0.000	2.15	1.90	2.42
Middle	0.000	1.70	1.52	1.89
Richer	0.000	1.37	1.24	1.52
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	2.15	1.89	2.45
Primary	0.000	1.70	1.48	1.95
Secondary	0.000	1.39	1.26	1.53
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.001	0.89	0.83	0.95
Birth Order				
1 *(Ref)*		1.00		
2	0.000	1.13	1.06	1.21
3	0.000	1.27	1.15	1.40
4 & above	0.015	1.21	1.04	1.42
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.29	1.19	1.39
Overweight	0.000	0.85	0.78	0.93
Obese	0.001	0.80	0.69	0.92

Table 4.5.2 shows the odds ratio of stunting in Under-5 children by socio-demographic variables in the Southern Region of India. Stunting children were 2.3 times higher in the aged group 12 – 23 months (OR: 2.36; 95% CI: 2.13 – 2.61; $p < 0.001$) as compared to children aged less than 12 months. As compared to children below the age of 12 months, the odds of stunting were 1.9 times greater in the age groups of 24 to 35 months (OR: 1.93; 95% CI: 1.75 – 2.13; $p < 0.001$) and 36 to 47 months (OR: 1.94; 95% CI: 1.76 – 2.14; $p < 0.001$). As Compared to children aged less than 12 months, the odds of stunting in the 48 to 59-month age group was 1.5 times greater (OR: 1.58; 95% CI: 1.42 – 1.75; $p < 0.001$). Male children (OR: 1.09; 95% CI: 1.03 – 1.16; $p = 0.004$) experienced significantly higher odds of being stunted children as compared to female children.

The odds of stunting were 2.2 times higher for the poorest group (OR: 2.21; 95% CI: 1.88 – 2.62; $p < 0.001$) than for the richest group. The odds of becoming stunted children were 2.1 times higher in the poorer group (OR: 2.15; 95% CI: 1.90 – 2.42; $p < 0.001$) compared to the richest group. As compared to the richest group, the middle group (OR: 1.70; 95% CI: 1.52 – 1.89; $p < 0.001$) had 1.7 times higher odds of having stunted children. In comparison to the richest group, the odds of having stunted children were 1.3 times higher in the richer group (OR: 1.37; 95% CI: 1.24 – 1.52; $p < 0.001$).

Women with no education (OR: 2.15; 95% CI: 1.89 – 2.45; $p < 0.001$) had 2.1 times greater odds of having stunted children than women with higher levels of education. Women with only primary education (OR: 1.70; 95% CI: 1.48 – 1.95; $p < 0.001$) had 1.7 times greater odds of producing stunted children than women with higher levels of education. Women with secondary education (OR: 1.39; 95% CI:

1.26 – 1.53; p < 0.001) had 1.3 times higher odds of having stunted children than women with higher education. As compared to urban regions, odds of children being stunted were 11% lower in rural areas (OR: 0.89; 95% CI: 0.83 – 0.95; p < 0.001).

As compared to the first birth order, children born in the second birth order (OR: 1.13; 95% CI: 1.06 – 1.21; p < 0.001) had odds of being stunted that were significantly higher. When compared to the first birth order, the risks of having children who are stunted were 1.2 times higher for the third birth order (OR: 1.27; 95% CI: 1.15 – 1.40; p < 0.001) and birth orders 4 and above (OR: 1.21; 95% CI: 1.04 – 1.42; p = 0.015). In comparison to normal mothers, those with underweight mothers (OR: 1.29; 95% CI: 1.19 – 1.39; p < 0.001) had 1.2 times the odds of having stunted children. As compared to normal mothers, those with overweight mothers (OR: 0.85; 95% CI: 0.78 – 0.93; p < 0.001) had 15% lesser odds of having stunted children. In comparison to normal mothers, those with obese mothers (OR: 0.80; 95% CI: 0.69 – 0.92; p < 0.001) had 20% lower odds of having children who were stunted.

Diagnostic Evaluation of Logistic Regression

Table 4.5.3 shows the model's sensitivity and specificity, which are 61% and 60.8%, respectively. However, sensitivity and specificity can be altered based on the requirements of the research and the requirement for diagnostic research. The area under the ROC curve is 0.650 (95% CI: 0.642 – 0.658) (Figure 4.5.2).

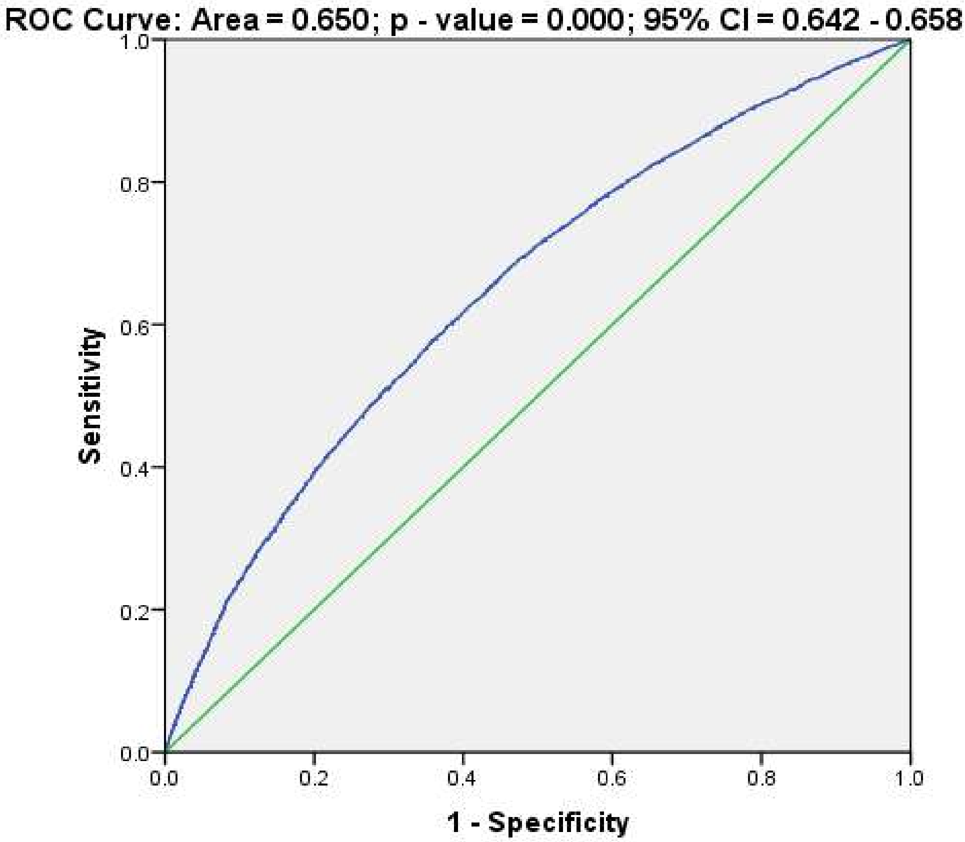


Figure.4.5.2: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Stunting in the Southern Region of India

Table 4.4.3: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.1498769	0.970	0.075
0.1515435	0.969	0.078
0.1608678	0.959	0.101
0.1680497	0.948	0.119
0.1743766	0.936	0.145
0.1805888	0.929	0.159
0.1854840	0.919	0.177
0.1919202	0.909	0.200
0.1989345	0.898	0.222
0.2037954	0.890	0.236
0.2038513	0.889	0.236
0.2068909	0.879	0.255
0.2124113	0.868	0.270
0.2620734	0.755	0.441
0.2634869	0.748	0.451
0.2648271	0.739	0.461
0.2704392	0.729	0.477
0.2748218	0.719	0.491
0.2789879	0.709	0.504
0.2811740	0.696	0.516
0.2859806	0.689	0.527
0.2868288	0.679	0.538
0.2971902	0.649	0.566
0.3067234	**0.610**	**0.608**
0.3070084	0.606	0.611
0.3385641	0.506	0.707
0.3408849	0.496	0.714
0.3828826	0.363	0.820
0.3884853	0.343	0.834
0.4441507	0.206	0.919
0.4524249	0.192	0.925

4.5.3 Wasting

Table 4.5.4: - Odds Ratio of Wasting in Under-5 Children by socio-demographic variables in Southern Region of India

Socio-demographic Variables	p - values	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	0.60	0.54	0.67
24 - 35	0.000	0.60	0.54	0.66
36 - 47	0.000	0.58	0.52	0.64
48 - 59	0.000	0.58	0.52	0.65
Child Sex				
Female *(Ref)*		1.00		
Male	0.000	1.15	1.08	1.23
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	1.70	1.41	2.03
Poorer	0.000	1.38	1.20	1.57
Middle	0.000	1.24	1.10	1.40
Richer	0.039	1.12	1.01	1.25
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.050	1.16	1.00	1.33
Primary	0.369	1.07	0.92	1.25
Secondary	0.253	1.06	0.96	1.18
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.008	0.90	0.83	0.97
Birth Order				
1 *(Ref)*		1.00		
2	0.611	1.02	0.95	1.10
3	0.401	1.05	0.94	1.17
4 & above	0.033	1.21	1.02	1.44
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.35	1.24	1.47
Overweight	0.000	0.78	0.71	0.86
Obese	0.000	0.59	0.49	0.70

Table 4.5.4 shows the odds ratio of wasting in under-5 children by socio-demographic variables in the southern region of India. Children in the age group 12 – 23 months (OR: 0.60; 95% CI: 0.54 – 0.67; p < 0.001) and 24 – 35 months (OR: 0.60; 95% CI: 0.54 – 0.66; p < 0.001) had 40% lower odds of being wasted compared to children under the age of 12 months. As compared to children under the age of 12 months, children in the age groups 36–47 months (OR: 0.58; 95% CI: 0.52 – 0.64; p < 0.001) and 48–59 months (OR: 0.58; 95% CI: 0.52 – 0.65; p < 0.001) had 42% lesser odds of being wasted. When compared to female children, male children (OR: 1.15; 95% CI: 1.08 – 1.23; p < 0.001) had significantly higher odds of being wasted.

The odds of being wasted children were 1.7 times greater for the poorest group (OR: 1.70; 95% CI: 1.41 – 2.03; p < 0.001) compared to the richest group. The odds of having wasted children was 1.3 times greater in the poorer group (OR: 1.38; 95% CI: 1.20 – 1.57; p < 0.001) compared to the richest group. In comparison to the richest group, the middle group (OR: 1.24; 95% CI: 1.10 – 1.40; p < 0.001) had 1.2 times higher odds of having wasted children. In comparison to the richest group, the richer group (OR: 1.12; 95% CI: 1.01 – 1.25; p = 0.039) had significantly higher odds of having wasted children.

When compared to women with higher levels of education, mothers without any formal education (OR: 1.16; 95% CI: 1.00 – 1.33; p = 0.050) had 1.5 times greater odds of having wasted children. Mothers with primary (OR: 1.07; 95% CI: 0.92 – 1.25; p = 0.369) and secondary education (OR: 1.06; 95% CI: 0.96 – 1.18; p = 0.253) had 1.1 times greater odds of having wasted children than mothers with higher levels of education. When compared to women with greater levels of education, there is no substantial difference in the likelihood of having wasted children among women with primary and secondary education. The odds of having wasted children was 10% lower in rural areas (OR: 0.90; 95% CI: 0.83 – 0.97; p = 0.008) than in urban areas.

The odds of having wasted children significantly higher in the second birth order (OR: 1.02; 95% CI: 0.95 – 1.10; p = 0.611) compared to the first. When comparing the third birth order (OR: 1.05; 95% CI: 0.94 – 1.17; p = 0.401) to the first birth order, the odds of having wasted children were 1.1 times higher. In comparison to the first birth order, the odds of having wasted children was 1.2 times higher in birth orders 4 and above (OR: 1.21; 95% CI: 1.02 – 1.44; p = 0.033). The likelihood of having wasted children in the second, third, fourth, and above birth orders are not significantly different compared to the first birth order.

As compared to normal mothers, underweight mothers (OR: 1.35; 95% CI: 1.24 – 1.47; p < 0.001) had 1.3 times higher odds of having wasted children. In comparison to normal mothers, overweight mothers (OR: 0.78; 95% CI: 0.71 – 0.86; p < 0.001) had 22% lesser odds of having wasted children (18.5 – 24.9). As compared to normal mothers, obese mothers (OR: 0.59; 95% CI: 0.49 – 0.70; p < 0.001) had 41% lesser odds of having wasted children (18.5 – 24.9).

Diagnostic Evaluation of Logistic Regression

According to Table 4.5.5, the model's sensitivity and specificity are 57.4% and 57.5%, respectively. However, depending on the needs of the study and the demand for diagnostic research, sensitivity and specificity may alter. Area under the ROC curve is 0.604 (95%CI: 0.594 – 0.613) (Figure 4.5.3).

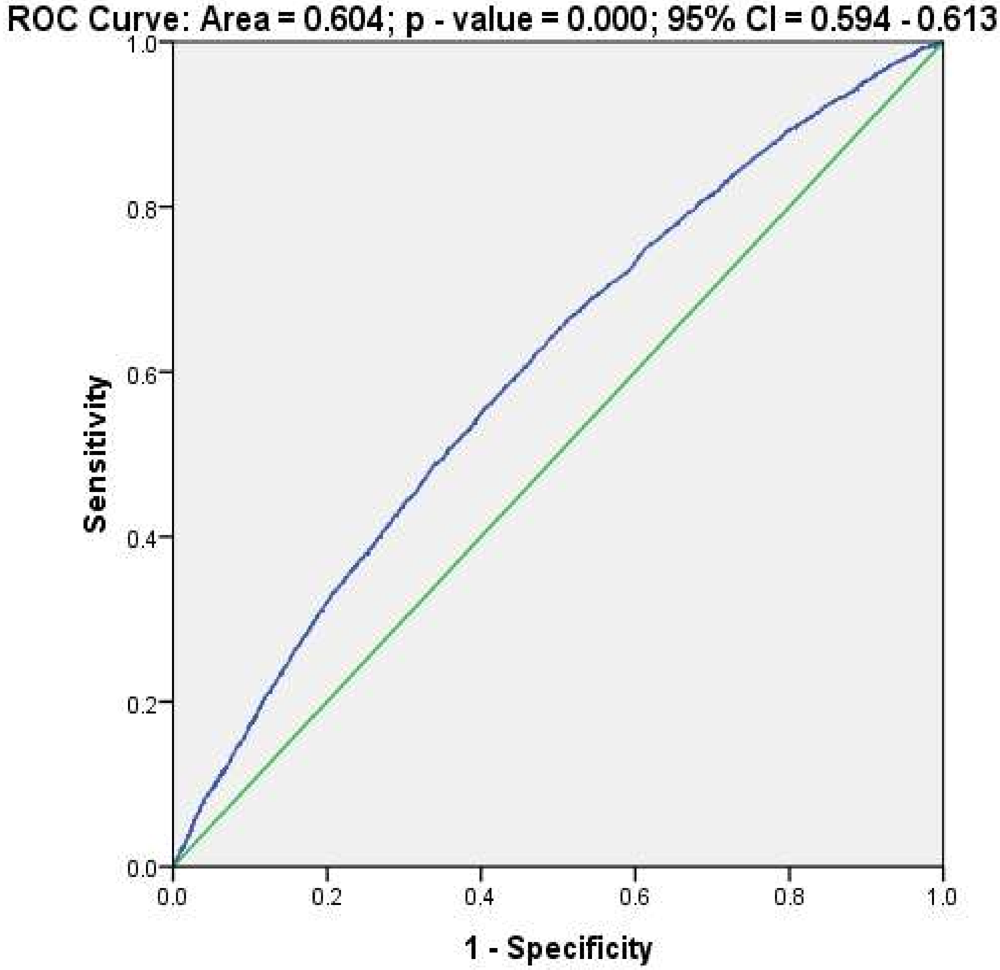


Figure 4.5.3: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Wasting in Southern Region of India

Table 4.5.5: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	**Sensitivity**	**Specificity**
0.1273605	0.970	0.070
0.1277318	0.969	0.073
0.1328585	0.959	0.088
0.1372932	0.950	0.106
0.1401344	0.938	0.119
0.1586045	0.869	0.231
0.1603148	0.859	0.246
0.1616136	0.849	0.260
0.1631897	0.839	0.272
0.1650876	0.829	0.283
0.1665154	0.821	0.291
0.1752166	0.767	0.362
0.1761533	0.758	0.374
0.1770673	0.749	0.387
0.1779162	0.739	0.395
0.1779841	0.739	0.396
0.1886542	0.669	0.479
0.1906205	0.659	0.490
0.1911454	0.649	0.501
0.1927245	0.635	0.515
0.1934995	0.629	0.519
0.1944284	0.619	0.531
0.1957029	0.608	0.540
0.1969705	0.597	0.552
0.1995076	0.581	0.569
0.1999691	**0.574**	**0.575**
0.2060424	0.538	0.609
0.2077008	0.523	0.624
0.2271928	0.412	0.722
0.2308218	0.396	0.736
0.2514605	0.292	0.820
0.2552514	0.275	0.832
0.2927362	0.132	0.925
0.3023137	0.109	0.939

4.5.4 Underweight

Table 4.5.6: - Odds Ratio of Underweight in Under-5 Children by socio-demographic variables in Southern Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	1.30	1.17	1.44
24 - 35	0.000	1.45	1.31	1.60
36 - 47	0.000	1.56	1.42	1.72
48 - 59	0.000	1.58	1.43	1.74
Child Sex				
Female *(Ref)*		1.00		
Male	0.003	1.10	1.03	1.16
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	3.30	2.79	3.91
Poorer	0.000	2.44	2.15	2.77
Middle	0.000	2.03	1.81	2.27
Richer	0.000	1.58	1.42	1.76
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.84	1.61	2.10
Primary	0.000	1.58	1.38	1.82
Secondary	0.000	1.35	1.22	1.49
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.000	0.85	0.79	0.91
Birth Order				
1 *(Ref)*		1.00		
2	0.020	1.08	1.01	1.16
3	0.000	1.24	1.12	1.36
4 & above	0.000	1.33	1.14	1.56
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.69	1.56	1.82
Overweight	0.000	0.83	0.76	0.90
Obese	0.000	0.68	0.59	0.80

Table 4.5.6 shows the odds ratio of underweight in Under-5 children by socio-demographic variables in the Southern Region of India. As compared to children under the age of 12 months, children aged group 12 – 23 months (OR: 1.30; 95% CI: 1.17 – 1.44, $p < 0.001$) had 1.3 times higher odds of being underweight children. Children between the ages of 24 and 35 months (OR: 1.45; 95% CI: 1.31 – 1.60, $p < 0.001$) had 1.4 times higher odds of being underweight than children under the age of 12 months. Children between the ages of 36 and 47 months (OR: 1.56; 95% CI: 1.42 – 1.72, $p < 0.001$) and ages of 48 and 59 months (OR: 1.58; 95% CI: 1.43 – 1.74, $p < 0.001$) had 1.5 times higher odds of being underweight than children under the age of 12 months. Children who were male (OR: 1.10; 95% CI: 1.03 – 1.16, $p = 0.003$) had significantly higher odds of being underweight than children who were female.

Underweight children are 3.3 times higher in the Poorest group (OR: 3.30; 95% CI: 2.79 – 3.91, $p < 0.001$) as compared to the Richest group. In comparison to the richest group, the odds of underweight children were 2.4 times higher in the poorer group (OR: 2.44; 95% CI: 2.15 – 2.77, $p < 0.001$). As compared to the Richest group, the odds of underweight children were two times higher in the Middle group (OR: 2.03; 95% CI: 1.81 – 2.27, $p < 0.001$). In richer group (OR: 1.58; 95% CI: 1.42 – 1.76, $p < 0.001$), odds of having underweight children were 1.5 times higher than richest group.

Mothers with no education (OR: 1.84; 95% CI: 1.61 – 2.10, $p < 0.001$) compared to those who had higher education, the odds of having underweight children were 1.8 times higher. Mothers with primary education (OR: 1.58; 95% CI: 1.38 – 1.82, $p < 0.001$) had 1.5 times greater odds of having underweight children than mothers with higher education levels. Mothers with secondary education (OR:

1.35; 95% CI: 1.22 – 1.49, $p < 0.001$) compared to those with a higher education level had 1.3 times greater odds of having underweight children. As compared to urban regions, odds of being underweight children was 15% lower in rural areas (OR: 0.85; 95% CI: 0.79 – 0.91, $p < 0.001$).

In the second birth order (OR: 1.08; 95% CI: 1.01 – 1.16, $p = 0.020$) compared to the first birth order, the odds of a child being underweight was 1.1 times higher. The odds of a children being underweight was 1.2 times higher in the third birth order (OR: 1.24; 95% CI: 1.12 – 1.36, $p < 0.001$) compared to the first birth order. In comparison to the first birth order, the odds that a child will be underweight was 1.3 times higher in the fourth and higher birth orders (OR: 1.33; 95% CI: 1.14 – 1.56, $p < 0.001$).

Underweight mothers (OR: 1.69; 95% CI: 1.56 – 1.82, $p < 0.001$) compared to normal mothers had 1.6 times higher odds of having underweight children. Overweight mothers (OR: 0.83; 95% CI: 0.76 – 0.90, $p < 0.001$) compared to normal mothers had 17% lesser odds of having underweight children. Obese mothers (OR: 0.68; 95% CI: 0.59 – 0.80, $p < 0.001$) compared to normal mothers had 32% lesser odds of having underweight children.

Diagnostic Evaluation of Logistic Regression

The model's sensitivity and specificity are 61.1% and 61.0%, respectively, according to Table 4.5.7. Sensitivity and specificity could change, though, depending on the objectives of the study and the need for diagnostic research. Area under the ROC Curve is 0.654 (95% CI: 0.646 – 0.662) (Figure 4.5.4).

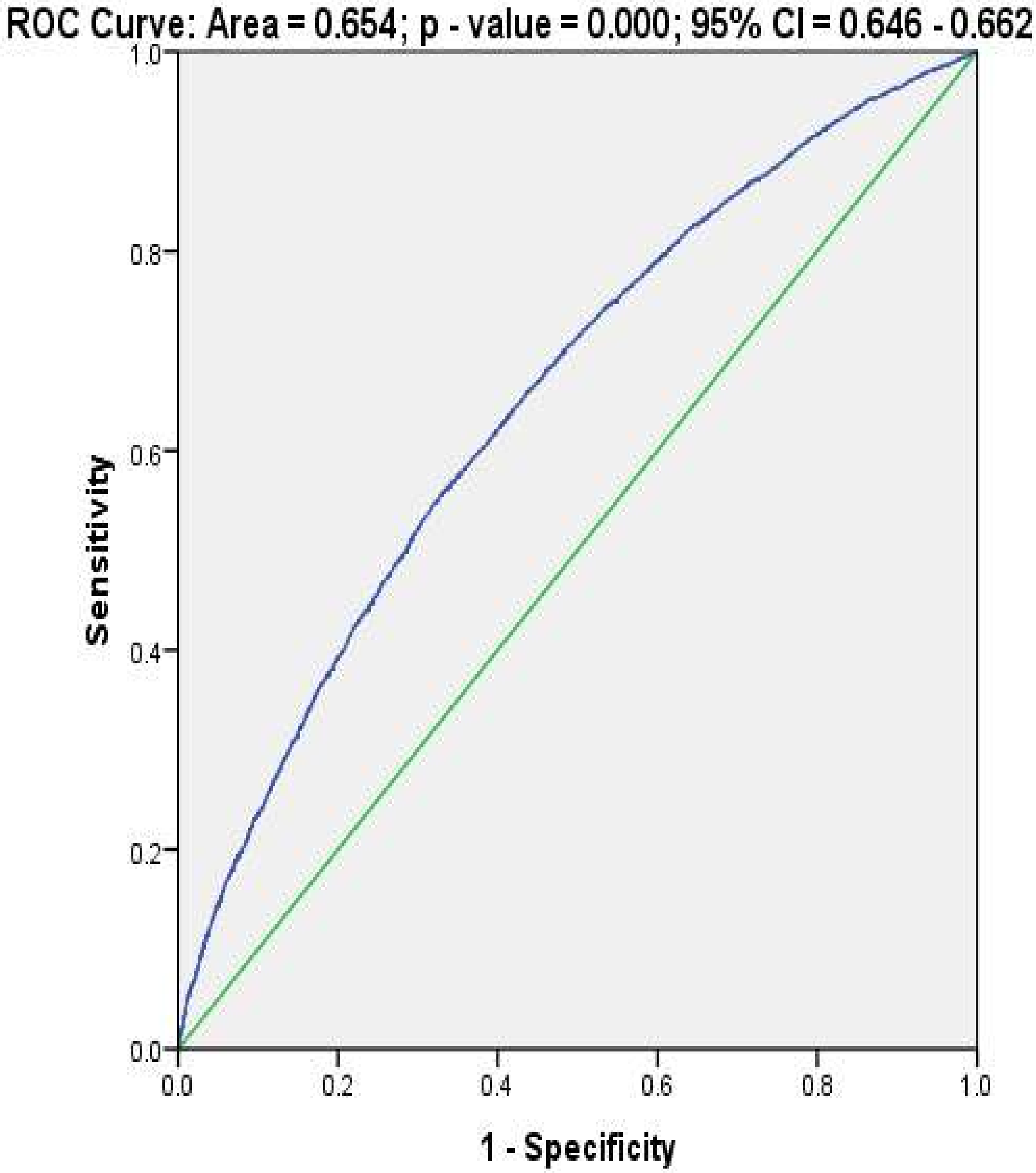


Figure. 4.5.4: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Underweight in Southern Region of India

Table 4.5.7: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	**Sensitivity**	**Specificity**
0.1352956	0.970	0.085
0.1366594	0.969	0.088
0.1421382	0.959	0.113
0.1509260	0.949	0.140
0.1607607	0.939	0.159
0.1654302	0.929	0.178
0.1738167	0.919	0.196
0.1813887	0.898	0.231
0.2040994	0.859	0.298
0.2071084	0.847	0.318
0.2089637	0.839	0.331
0.2171510	0.829	0.347
0.2205420	0.819	0.364
0.2264376	0.797	0.391
0.2357513	0.776	0.418
0.2457491	0.748	0.456
0.2510361	0.739	0.470
0.2525349	0.728	0.482
0.2598291	0.699	0.518
0.2660760	0.689	0.527
0.2699796	0.669	0.550
0.2723234	0.659	0.563
0.2881948	**0.611**	**0.610**
0.2882388	0.609	0.611
0.3114371	0.514	0.706
0.3170967	0.501	0.713
0.3623904	0.368	0.818
0.3671495	0.353	0.829
0.4246954	0.218	0.911
0.4370505	0.189	0.928

4.5.5 Estimation of Child Height

Table 4.5.8 represents the test between subjects' effects, reveals child age, education level, wealth index, child sex is having a significant effect on Child Height except type of residence, birth order, respondent occupation, and BMI.

Table 4.5.8: Tests of Between-Subjects Effects

Dependent Variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	509.698	1	509.698	10.984	< 0.001
	Error	21716.006	467.98	46.404a		
Child Age	Hypothesis	594.616	4	148.654	3.347	0.010
	Error	201107.788	4528	44.414b		
Birth Order	Hypothesis	293.192	3	97.731	2.200	0.086
	Error	201107.788	4528	44.414b		
Education Level	Hypothesis	1144.535	3	381.512	8.590	< 0.001
	Error	201107.788	4528	44.414b		
Respondent Occupation	Hypothesis	127.373	2	63.687	1.434	0.238
	Error	201107.788	4528	44.414b		
Type Of Residence	Hypothesis	16.405	1	16.405	0.369	0.543
	Error	201107.788	4528	44.414b		
Wealth Index	Hypothesis	834.919	4	208.73	4.700	< 0.001
	Error	201107.788	4528	44.414b		
BMI	Hypothesis	163.178	3	54.393	1.225	0.299
	Error	201107.788	4528	44.414b		
Child Sex	Hypothesis	1749.898	1	1749.898	39.399	< 0.001
	Error	201107.788	4528	44.414b		
FIT*	Hypothesis	46951.403	1	46951.403	1057.124	< 0.001
	Error	201107.788	4528	44.414b		
Birth Weight	Hypothesis	320.052	1	320.052	7.206	0.007
	Error	201107.788	4528	44.414b		
a .001 MS (Child Sex) + .999 MS (Error)						
b MS(Error)						

**Note: - ***Fit for Child height with Child age from CURVEFIT using Cubic Model –
$$Child\ Height = 54.590 + 1.747\ Child\ age - 0.0029\ Child\ age^2 + 0.000225\ Child\ age^3$$

Table 4.5.9 represents factors associated with child height in southern region. Children born in the first birth order (OR: 2.61, 95% CI: 0.92 – 7.40, p = 0.072) have a height which is 2.6 times higher than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.70, 95% CI: 1.60 – 4.82, p = 0.320) have a height which is higher than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.53, 95% CI: 0.49 – 4.74, p = 0.463) have a height which is higher than children born in the 4 & above birth order.

Children's height is 90% less in mothers with no education (OR: 0.10, 95% CI: 0.04 – 0.25, p < 0.05) compared to mothers with higher education. Children's height is 63% less in mothers with primary education (OR: 0.37, 95% CI: 0.15 – 0.88, p < 0.05) compared to mothers with higher education. Children's height is 50% less in mothers with secondary education (OR: 0.50, 95% CI: 0.29 – 0.87, p < 0.05) compared to mothers with higher education.

Children's height is more in mothers with no occupation (OR: 1.8, 95% CI: 0.91 – 3.58, p = 0.091) compared to agricultural mothers. As compared to agricultural mothers, the height of children is more in mothers with other occupations (OR: 1.76, 95% CI: 0.73 – 4.25, p = 0.206). As compared to rural region, the height of children is more in urban region (OR: 1.15, 95% CI: 0.74 – 1.78, p = 0.543).

Children in the poorest group (OR: 0.17, 95% CI: 0.05 – 0.53, p < 0.05) have 83% less height than children in the richest group. Children in the poorer group (OR: 0.22, 95% CI: 0.10 – 0.48, p < 0.05) have 78% less height than children in the richest group. Children in the middle group (OR: 0.56, 95% CI: 0.29 – 1.07, p = 0.080) have 44% less height than children in the richest group. Children in the richer group (OR:

0.55, 95% CI: 0.30 – 0.98, $p < 0.05$) have 45% less height than children in the richest group.

The height of children with normal BMI (OR: 1.01, 95% CI: 0.45 – 2.28, $p = 0.982$) is more than that of those with obese BMI. The height of children with underweight BMI (OR: 0.60, 95% CI: 0.24 – 1.51, $p = 0.279$) is 40% lesser than that of children with obese BMI. The height of children with overweight BMI (OR: 0.99, 95% CI: 0.41 – 2.37, $p = 0.983$) is less than that of children with obese BMI. As compared to female children, height of male children (OR: 3.47, 95% CI: 2.35 – 5.11, $p < 0.05$) is 3 times higher.

Table 4.5.9: Factors Associated with Child Height in Southern Region

Dependent Variable: Child Height					
Parameter	B	p - value	95% CI		OR (95%CI)
			LL	UL	
Birth Order					
1	0.958	0.072	-0.086	2.002	2.61 (0.92, 7.40)
2	0.529	0.320	-0.513	1.572	1.70 (0.60, 4.82)
3	0.424	0.463	-0.708	1.556	1.53 (0.49, 4.74)
4 & above *(Ref.)*	0				
Education Level					
No Education	-2.273	0.000	-3.158	-1.388	0.10 (0.04, 0.25)
Primary	-1.006	0.025	-1.886	-0.125	0.37 (0.15, 0.88)
Secondary	-0.692	0.015	-1.249	-0.136	0.50 (0.29, 0.87)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	0.59	0.091	-0.094	1.275	1.80 (0.91, 3.58)
Other	0.568	0.206	-0.312	1.447	1.76 (0.73, 4.25)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	0.137	0.543	-0.304	0.577	1.15 (0.74, 1.78)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-1.772	0.002	-2.902	-0.642	0.17 (0.05, 0.53)
Poorer	-1.507	0.000	-2.277	-0.738	0.22 (0.10, 0.48)
Middle	-0.581	0.080	-1.232	0.07	0.56 (0.29, 1.07)
Richer	-0.606	0.043	-1.193	-0.02	0.55 (0.30, 0.98)
Richest *(Ref.)*	0				
BMI					
Normal	0.01	0.982	-0.805	0.824	1.01 (0.45, 2.28)
Underweight	-0.506	0.279	-1.422	0.41	0.60 (0.24, 1.51)
Overweight	-0.009	0.983	-0.882	0.864	0.99 (0.41, 2.37)
Obese *(Ref.)*	0				
Child Sex					
Male	1.244	0.000	0.855	1.632	3.47 (2.35, 5.11)
Female *(Ref.)*	0				
FIT*	1.093	0.000	1.027	1.159	2.98 (2.79, 3.19)
Birth Weight	0.727	0.007	0.196	1.257	2.07 (1.22, 3.51)

**Note: - ***Fit for Child height with Child age from CURVEFIT using Cubic Model –
$Child\ Height = 54.590 + 1.747\ Child\ age - 0.0029\ Child\ age^2 + 0.000225\ Child\ age^3$

Table 4.5.10 represents the descriptive statistics of child height by birth order. The mean height of a child in first and second birth order is around 84.6 cm and 84.1 cm, respectively. The mean height of a child in third and 4 & above birth order is around 84 cm and 83.6 cm, respectively.

Table 4.5.10: - Descriptive Statistics of Child Height by Birth Order

Dependent Variable: Child Height				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	84.61	0.24	84.13	85.08
2	84.18	0.24	83.71	84.65
3	84.08	0.33	83.43	84.72
4 & above	83.65	0.52	82.63	84.67

Table 4.5.11 represents a pairwise comparison of child height by birth order. Mean difference of child height between first and second birth order (M D = 0.428, 95% CI: -0.001 to 0.858, p = 0.051), between first and third birth order (M D = 0.534, 95% CI: -0.119 to 1.186, p = 0.109) is statistically insignificant. Also, mean difference of child height between first and 4 & above birth order (M D = 0.958, 95% CI: -0.086 to 2.002, p = 0.072) is statistically insignificant. Mean difference of child height between second and third birth order (M D = 0.105, 95% CI: -0.549 to 0.759, p = 0.753) is statistically insignificant. Also, mean difference of child height between second and 4 & above birth order (M D = 0.529, 95% CI: -0.513 to 1.572, p = 0.320) is statistically insignificant. Mean difference of child height between third and 4 & above birth order (M D = 0.424, 95% CI: -0.708 to 1.556, p = 0.463) is statistically insignificant.

Table 4.5.11: - Pairwise Comparisons of Child Height by Birth Order

Dependent Variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
1	2	0.428	0.219	0.051	-0.001	0.858
	3	0.534	0.333	0.109	-0.119	1.186
	4 & above	0.958	0.533	0.072	-0.086	2.002
2	3	0.105	0.334	0.753	-0.549	0.759
	4 & above	0.529	0.532	0.32	-0.513	1.572
3	4 & above	0.424	0.577	0.463	-0.708	1.556

Table 4.5.12 represents the descriptive statistics of child height by educational level. The mean height of a child for mothers with no education is around 82.8 cm. For mothers with primary education, average height of the child is around 84.1 cm. For mothers with secondary education, average height of the child is around 84.4 cm. Similarly, for mothers with higher education, the average child's height is around 85 cm.

Table 4.5.12: - Descriptive Statistics of Child Height by Educational Level

Dependent Variable: Child Height				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	82.85	0.36	82.15	83.55
Primary	84.12	0.38	83.37	84.87
Secondary	84.43	0.25	83.95	84.91
Higher	85.12	0.34	84.47	85.78

Table 4.5.13 represents a pairwise comparison of child height by educational level. Mean difference of child height between mothers with no education and primary education (M D = -1.268, 95% CI: -2.18 to -0.36, $p < 0.05$), no education and secondary education (M D = -1.581, 95% CI: -2.30 to -0.86, $p < 0.05$) and no education and higher education (M D = -2.273, 95% CI: -3.16 to -1.39, $p < 0.05$) is statistically significant. Mean difference of child height between mothers with primary and secondary education (M D = -0.314, 95% CI: -1.04 to 0.41, $p = 0.395$) is statistically insignificant. Mean difference of child height between mothers with primary and higher education (M D = -1.006, 95% CI: -1.89 to -0.13, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.692, 95% CI: -1.25 to -0.14, $p < 0.05$) is statistically significant.

Table 4.5.13: - Pairwise Comparisons of Child Height by Highest Educational Level

Dependent Variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
No education	Primary	-1.268*	0.46	0.006	-2.18	-0.36
	Secondary	-1.581*	0.37	0.000	-2.30	-0.86
	Higher	-2.273*	0.45	0.000	-3.16	-1.39
Primary	Secondary	-0.314	0.37	0.395	-1.04	0.41
	Higher	-1.006*	0.45	0.025	-1.89	-0.13
Secondary	Higher	-.692*	0.28	0.015	-1.25	-0.14
*Mean difference is significant at the 0.05 level.						

Table 4.5.14 represents the descriptive statistics of child height by respondent occupation. Mean height of the child for mothers with no occupation is around 84.3 cm. But, for mothers with other occupation and agricultural mothers, average height of the child is around 84.3 cm and 83.7 cm, respectively.

Table 4.5.14: - Descriptive Statistics of Child Height by Respondent Occupation

Dependent Variable: Child Height				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	84.33	0.21	83.92	84.75
Other	84.31	0.35	83.62	85.00
Agriculture	83.74	0.36	83.05	84.44

Table 4.5.15 represents a pairwise comparison of child height by respondent occupation. Mean difference of child height between mothers with no occupation and mothers with other occupation (M D = 0.02, 95% CI: -0.61 to 0.65, p = 0.944) is statistically insignificant. Similarly, mean difference of child height between mothers with no occupation and mothers doing agriculture (M D = 0.59, 95% CI: -0.09 to 1.28, p = 0.091) is statistically insignificant. Mean difference of child height between mothers with other occupation and mothers doing agriculture (M D = 0.57, 95% CI: -0.31 to 1.45, p = 0.206) is statistically insignificant.

Table 4.5.15: - Pairwise Comparisons of Child Height by Respondent Occupation

Dependent Variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
No Occupation	Other	0.02	0.32	0.944	-0.61	0.65
	Agriculture	0.59	0.35	0.091	-0.09	1.28
Other	Agriculture	0.57	0.45	0.206	-0.31	1.45

Table 4.5.16 represents the descriptive statistics of Child Height by Type of Residence. Mean height of child in urban as well as rural regions is around 84.1 cm and 84 cm, respectively.

Table 4.5.16: - Descriptive Statistics of Child Height by Type of Residence

Dependent Variable: Child Height				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	84.197	0.268	83.672	84.723
Rural	84.061	0.235	83.6	84.521

Table 4.5.17 represents a pairwise comparison of child height by Type of Residence. Mean difference of child height between urban region and rural region (M D = 0.091, 95% CI: -0.304 to 0.577, p-value = 0.543), is statistically insignificant.

Table 4.5.17: - Pairwise Comparisons of Child Height by Type of Residence

Dependent Variable: Child Height						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p – value	95% CI for Difference	
					LL	UL
Urban	Rural	0.091	0.225	0.543	-0.304	0.577

Table 4.5.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 83 cm. In the poorer and middle groups, children's average height is around 83.5 cm and 84.4 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 84.4 cm and 85 cm, respectively.

Table 4.5.18: - Descriptive Statistics of Child Height by Wealth Index

Dependent Variable: Child Height				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	83.25	0.51	82.24	84.26
Poorer	83.52	0.31	82.90	84.13
Middle	84.44	0.28	83.89	84.99
Richer	84.42	0.28	83.88	84.96
Richest	85.02	0.32	84.40	85.64

Table 4.5.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and middle group (M D = -1.191, 95% CI: -2.21 to -0.17, p < 0.05), between poorest group and richer group (M D = -1.166, 95% CI: -2.22 to -0.11, p < 0.05), and between poorest group and richest group (M D = -1.772, 95% CI: -2.90 to –0.64, p < 0.05) is statistically significant. Mean difference of child height between poorer group and middle group (M D = - 0.926, 95% CI: - 1.54 to – 0.31, p < 0.05), between poorer group and richer group (M D = - 0.901, 95% CI: -1.56 to – 0.25, p < 0.05), and between poorer group and richest group (M D = -1.507, 95% CI: -2.28 to –0.74, p < 0.05) is statistically significant. Mean difference of child height between richer and richest group (M D = -0.606, 95% CI: -1.19 to –0.02, p < 0.05) is statistically significant.

Table 4.5.19: - Pairwise Comparisons of Child Height by Wealth Index

Dependent Variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p – value	95% CI for Difference	
					LL	UL
Poorest	Poorer	-0.265	0.53	0.620	-1.31	0.78
	Middle	-1.191*	0.52	0.022	-2.21	-0.17
	Richer	-1.166*	0.54	0.030	-2.22	-0.11
	Richest	-1.772*	0.58	0.002	-2.90	-0.64
Poorer	Middle	-0.926*	0.31	0.003	-1.54	-0.31
	Richer	-0.901*	0.34	0.007	-1.56	-0.25
	Richest	-1.507*	0.39	0.000	-2.28	-0.74
Middle	Richer	0.025	0.27	0.925	-0.51	0.56
	Richest	-0.581	0.33	0.080	-1.23	0.07
Richer	Richest	-0.606*	0.30	0.043	-1.19	-0.02
*Mean difference is significant at the 0.05 level.						

Table 4.5.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 84.7 cm. Similarly, children's average height in females is around 83.5 cm.

Table 4.5.20: - Descriptive Statistics of Child Height by Child Sex

Dependent Variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	84.751	0.244	84.273	85.229
Female	83.507	0.249	83.018	83.995

Table 4.5.21 represents a pairwise comparison of child height by Child Sex. Mean difference of child height between in male children and female children (M D = 1.244, 95% CI: 0.86 to 1.63, $p < 0.05$) is statistically significant.

Table 4.5.21: - Pairwise Comparisons of Child Height by Child Sex

Dependent Variable: Child Height						
Sex of child	Sex of child	Mean Difference	Std. Error	p – value	95% CI for Difference	
					LL	UL
Male	Female	1.244*	0.20	0.000	0.86	1.63
*Mean difference is significant at the 0.05 level.						

Table 4.5.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as in underweight BMI is around 84.2 cm and 83.7 cm. The average height of a child with an overweight BMI is around 84.2 cm. Similarly, children's average height in obese BMI is around 84.2 cm.

Table 4.5.22: - Descriptive Statistics of Child Height by BMI

Dependent Variable: Child Height				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	84.27	0.23	83.82	84.71
Underweight	83.75	0.30	83.16	84.34
Overweight	84.25	0.29	83.67	84.82
Obese	84.26	0.43	83.41	85.11

Table 4.5.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.52, 95% CI: -0.02 to 1.05, p = 0.06), between normal BMI and overweight BMI (M D = 0.02, 95% CI: -0.49 to 0.53, p = 0.942), and between normal BMI and obese BMI (M D = 0.01, 95% CI: -0.81 to 0.82, p = 0.982) is statistically insignificant. Mean difference of child height between underweight BMI and overweight BMI (M D = -0.50, 95% CI: -1.15 to 0.16, p = 0.14) and between underweight BMI and obese BMI (M D = -0.51, 95% CI: -1.42 to 0.41, p = 0.279) is statistically insignificant. Mean difference of child height between overweight BMI and obese BMI (M D = -0.01 95% CI: -0.88 to 0.86, p = 0.983) is statistically insignificant.

Table 4.5.23: - Pairwise Comparisons of Child Height by BMI

Dependent Variable: Child Height						
BMI	BMI	Mean Difference	Std. Error	p – value	95% CI for Difference	
					LL	UL
Normal	Underweight	0.52	0.27	0.06	-0.02	1.05
	Overweight	0.02	0.26	0.942	-0.49	0.53
	Obese	0.01	0.42	0.982	-0.81	0.82
Underweight	Overweight	-0.50	0.34	0.14	-1.15	0.16
	Obese	-0.51	0.47	0.279	-1.42	0.41
Overweight	Obese	-0.01	0.45	0.983	-0.88	0.86

4.5.6 Estimation of Child Weight

Table 4.5.24 represents the test between subjects' effects, reveals child age, birth order, educational level, wealth index, sex of child and BMI is having a significant effect on Child Weight except respondent occupation, place of residence.

Table 4.5.24: Tests of Between-Subjects Effects

Dependent Variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	63.513	1	63.513	14.942	< 0.001
	Error	164.446	38.687	4.251a		
Child Age	Hypothesis	178.943	4	44.736	12.487	< 0.001
	Error	16186.104	4518	3.583b		
Birth Order	Hypothesis	91.325	3	30.442	8.497	< 0.001
	Error	16186.104	4518	3.583b		
Educational Level	Hypothesis	61.99	3	20.663	5.768	< 0.001
	Error	16186.104	4518	3.583b		
Respondent Occupation	Hypothesis	11.277	2	5.638	1.574	0.207
	Error	16186.104	4518	3.583b		
Place of Residence	Hypothesis	3.207	1	3.207	0.895	0.344
	Error	16186.104	4518	3.583b		
Wealth Index	Hypothesis	188.279	4	47.07	13.138	< 0.001
	Error	16186.104	4518	3.583b		
BMI	Hypothesis	197.504	3	65.835	18.376	< 0.001
	Error	16186.104	4518	3.583b		
Child Sex	Hypothesis	184.446	1	184.446	51.484	< 0.001
	Error	16186.104	4518	3.583b		
FIT*	Hypothesis	2606.629	1	2606.629	727.584	< 0.001
	Error	16186.104	4518	3.583b		
Birth Weight	Hypothesis	99.704	1	99.704	27.83	< 0.001
	Error	16186.104	4518	3.583b		
a .004 MS (Child Sex) + .996 MS (Error)						
b MS(Error)						

**Note: ***Fit for Child Weight with Child Age from CURVEFIT using Power Model:

$$Child\ Weight = 3.324\ Child\ Age^{0.355}$$

Table 4.5.25 represents factors associated with child weight in southern region. When compared to children between the ages of 48 and 59 months, children under the age of 12 months (OR: 1.60, 95% CI: 0.87 – 2.97, p = 0.132) weigh around 2 times more. The weight of children between the ages of 12 and 23 months (OR: 0.92, 95% CI: 0.62 – 1.37, p = 0.687) is 8% lesser than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.78, 95% CI: 0.59 – 1.03, p = 0.079) weigh 22% lesser than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.72, 95% CI: 0.59 – 0.87, p < 0.05) weigh 28% less.

Children born in the first birth order (OR: 1.86, 95% CI: 1.38 – 2.50, p < 0.05) weigh more than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.51, 95% CI: 1.12 – 2.02, p < 0.05) weigh also more than children born in the 4 & above birth order. Similarly, children born in the third birth order (OR: 1.43, 95% CI: 1.03 – 1.96, p < 0.05) weigh more than children born in the 4 & above birth order.

Children's weight is 41% less in mothers with no education (OR: 0.59, 95% CI: 0.46 – 0.76, p < 0.05) compared to mothers with higher education. Children's weight is 25% less in mothers with primary education (OR: 0.75, 95% CI: 0.59 – 0.97, p < 0.05) compared to mothers with higher education. Children's weight is 21% less in mothers with secondary education (OR: 0.79, 95% CI: 0.68 – 0.93, p < 0.05) compared to mothers with higher education.

Children's weight is more in mothers with no occupation (OR: 1.19, 95% CI: 0.98 – 1.44, p = 0.080) compared to agricultural mothers. As compared to agricultural mothers, the weight of children is more in mothers with other occupations

(OR: 1.14, 95% CI: 0.89 – 1.46, p = 0.306). As compared to rural region, the weight of children is 6% less in urban region (OR: 0.94, 95% CI: 0.83 – 1.07, p = 0.344).

Children in the poorest group (OR: 0.38, 95% CI: 0.28 – 0.52, $p < 0.05$) have 62% less weight than children in the richest group. Children in the poorer group (OR: 0.51, 95% CI: 0.41 – 0.64, $p < 0.05$) have 49% less weight than children in the richest group. Children in the middle group (OR: 0.64, 95% CI: 0.54 – 0.77, $p < 0.05$) have 36% less weight than children in the richest group. Children in the richer group (OR: 0.81, 95% CI: 0.68 – 0.96, $p < 0.05$) have 19% less weight than children in the richest group.

The weight of children with normal woman (OR: 0.66, 95% CI: 0.53 – 0.84, $p < 0.05$) is 34% lesser than that of those with obese woman. The weight of children with underweight woman (OR: 0.44, 95% CI: 0.34 – 0.57, $p < 0.05$) is around 56% lesser than that of children with obese woman. The weight of children with overweight woman (OR: 0.81, 95% CI: 0.63 – 1.03, p = 0.088) is 19% lesser than that of children with obese woman. As compared to female children, weight of male children (OR: 1.50, 95% CI: 1.34 – 1.67, $p < 0.05$) is around 2 times higher.

Table 4.5.25: Factors Associated with Child Weight in Southern Region

Dependent Variable: Child Weight					
Parameter	B	p - value	95% CI LL	95% CI UL	OR (95% CI)
Child Age (Months)					
< 12	0.473	0.132	-0.142	1.087	1.60 (0.87, 2.97)
12 - 23	-0.082	0.687	-0.482	0.318	0.92 (0.62, 1.37)
24 - 35	-0.25	0.079	-0.528	0.029	0.78 (0.59, 1.03)
36 - 47	-0.334	0.001	-0.533	-0.135	0.72 (0.59, 0.87)
48 – 59 *(Ref.)*	0				
Birth Order					
1	0.619	0.000	0.324	0.915	1.86 (1.38, 2.50)
2	0.409	0.007	0.114	0.704	1.51 (1.12, 2.02)
3	0.355	0.030	0.034	0.675	1.43 (1.03, 1.96)
4 & above *(Ref.)*	0				
Education Level					
No Education	-0.528	0.000	-0.779	-0.277	0.59 (0.46, 0.76)
Primary	-0.283	0.027	-0.533	-0.032	0.75 (0.59, 0.97)
Secondary	-0.232	0.004	-0.39	-0.073	0.79 (0.68, 0.93)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	0.174	0.080	-0.021	0.368	1.19 (0.98, 1.44)
Others	0.131	0.306	-0.119	0.38	1.14 (0.89, 1.46)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	-0.06	0.344	-0.186	0.065	0.94 (0.83, 1.07)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-0.967	0.000	-1.29	-0.645	0.38 (0.28, 0.52)
Poorer	-0.664	0.000	-0.883	-0.445	0.51 (0.41, 0.64)
Middle	-0.44	0.000	-0.625	-0.255	0.64 (0.54, 0.77)
Richer	-0.213	0.012	-0.38	-0.046	0.81 (0.68, 0.96)
Richest *(Ref.)*	0				
BMI					
Normal	-0.409	0.001	-0.641	-0.177	0.66 (0.53, 0.84)
Underweight	-0.82	0.000	-1.08	-0.559	0.44 (0.34, 0.57)
Overweight	-0.216	0.088	-0.464	0.033	0.81 (0.63, 1.03)
Obese *(Ref.)*	0				
Child Sex					
Male	0.404	0.000	0.294	0.515	1.50 (1.34, 1.67)
Female *(Ref.)*	0				
FIT*	1.109	0.000	1.028	1.189	3.03 (2.80, 3.28)
Birth Weight	0.406	0.000	0.255	0.556	1.50 (1.29, 1.74)

**Note: ***Fit for Child Weight with Child Age from CURVEFIT using Power Model:

$$Child\ Weight = 3.324\ Child\ Age^{0.355}$$

Table 4.5.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in less than 12 months age group is around 11.1 kg. The mean weight of a child in 12 - 23 months and 24 - 35 months age group is around 10.5 kg and 10.4 kg, respectively. The mean weight of a child in 36 - 47 months age group is around 10.3 kg. The mean weight of a child in 48 - 59 months age group is around 10.6 kg.

Table 4.5.26: Descriptive Statistics of Child Weight by Child Age

Dependent Variable: Child Weight				
Child Age	Mean	Std. Error	95% CI	
			LL	UL
< 12	11.114	0.193	10.736	11.493
12 - 23	10.559	0.102	10.36	10.759
24 - 35	10.392	0.088	10.22	10.563
36 - 47	10.307	0.114	10.084	10.531
48 - 59	10.641	0.154	10.339	10.944

Table 4.5.27 represents a pairwise comparison of child weight by child age. Mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.555, 95% CI: 0.264 to 0.845, $p < 0.05$) is statistically significant. Mean difference of child weight between less than 12 months and 24 – 35 months age group (M D = 0.722, 95% CI: 0.311 to 1.134, $p < 0.05$) and between less than 12 months and 36 – 47 months age group (M D = 0.807, 95% CI: 0.286 to 1.328, $p < 0.05$) is statistically significant. Mean difference of child weight between 36 - 47 months and 48 -59 months age group (M D = -0.334, 95% CI: -0.533 to - 0.135, $p < 0.05$) is statistically significant.

Table 4.5.27: Pairwise Comparisons of Child Weight by Child Age

Dependent Variable: Child Weight						
Child Age	Child Age	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
< 12	12 - 23	0.555*	0.148	0.000	0.264	0.845
	24 - 35	0.722*	0.21	0.001	0.311	1.134
	36 - 47	0.807*	0.266	0.002	0.286	1.328
	48 - 59	0.473	0.314	0.132	-0.142	1.087
12 - 23	24 - 35	0.168	0.115	0.145	-0.058	0.393
	36 - 47	0.252	0.16	0.114	-0.061	0.565
	48 - 59	-0.082	0.204	0.687	-0.482	0.318
24 - 35	36 - 47	0.084	0.106	0.427	-0.123	0.292
	48 - 59	-0.25	0.142	0.079	-0.528	0.029
36 - 47	48 - 59	-0.334*	0.101	0.001	-0.533	-0.135
*Mean difference is significant at the .05 level.						

Table 4.5.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in the first birth order is around 10.8 kg. The mean weight of a child in the second and third birth order is around 10.6 kg. For 4 & above birth order, mean weight of a child is around 10.2 kg.

Table 4.5.28: Descriptive Statistics of Child Weight by Birth Order

Dependent Variable: Child Weight				
Birth order	Mean	Std. Error	95% CI	
			LL	UL
1	10.876	0.069	10.742	11.011
2	10.666	0.068	10.533	10.799
3	10.612	0.094	10.428	10.795
4 & above	10.257	0.148	9.967	10.547

Table 4.5.29 represents a pairwise comparison of child weight by birth order. Mean difference of child weight between first and second birth order (M D = 0.210, 95% CI: -0.088 to - 0.333, $p < 0.05$), between first and third birth order (M D = 0.265, 95% CI: -0.079 to - 0.450, $p < 0.05$) and between first and 4 & above birth order (M D = 0.619, 95% CI: -0.324 to 0.915, $p < 0.05$) is statistically significant. The mean difference in children weight between second and third birth orders (M D = 0.054, 95% CI: -0.132 to 0.240, $p = 0.568$) is statistically insignificant. Mean difference of

child weight between second and 4 & above birth orders (M D = 0.409, 95% CI: 0.114 to 0.704, $p < 0.05$) is statistically significant. The mean difference in children weight between third and 4 & above birth orders (M D = 0.355, 95% CI: 0.034 to 0.675, $p < 0.05$).

Table 4.5.29: Pairwise Comparison of Child Weight by Birth Order

Dependent Variable: Child Weight						
Birth order	Birth order	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
1	2	0.210*	0.062	0.001	0.088	0.333
	3	0.265*	0.095	0.005	0.079	0.450
	4 & above	0.619*	0.151	0.000	0.324	0.915
2	3	0.054	0.095	0.568	-0.132	0.240
	4 & above	0.409*	0.151	0.007	0.114	0.704
3	4 & above	0.355*	0.164	0.030	0.034	0.675
*Mean difference is significant at the 0.05 level.						

Table 4.5.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 10.3 kg. For mothers with primary education, average weight of the child is around 10.5 kg. For mothers with secondary education, average weight of the child is around 10.6 kg. Similarly, for mothers with higher education, the average child's weight is around 10.8 kg.

Table 4.5.30: Descriptive Statistics of Child Weight by Educational Level

Dependent Variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	10.335	0.101	10.137	10.533
Primary	10.581	0.109	10.368	10.794
Secondary	10.632	0.070	10.494	10.769
Higher	10.863	0.095	10.677	11.050

Table 4.5.31 represents a pairwise comparison of child weight by educational level. Mean difference of child weight between mothers with no education and primary education (M D = -0.246, 95% CI: -0.503 to 0.012, p = 0.061) is statistically insignificant. Mean difference of child weight between mothers with no education and secondary education (M D = -0.297, 95% CI: - 0.500 to -0.093, $p < 0.05$) and between mothers with no education and higher education (M D = 0.528, 95% CI: - 0.779 to - 0.277, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with primary and secondary education (M D = -0.051, 95% CI: - 0.256 to 0.155, p = 0.628) is statistically insignificant. Mean difference of child weight between mothers with primary and higher education (M D = - 0.283, 95% CI: -0.533 to -0.032, $p < 0.05$) is statistically significant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.232, 95% CI: -0.390 to -0.073, $p < 0.05$) is statistically significant.

Table 4.5.31: Pairwise Comparison of Child Weight by Educational Level

Dependent Variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No education	Primary	-0.246	0.131	0.061	-0.503	0.012
	Secondary	-0.297*	0.104	0.004	-0.500	-0.093
	Higher	-0.528*	0.128	0.000	-0.779	-0.277
Primary	Secondary	-0.051	0.105	0.628	-0.256	0.155
	Higher	-0.283*	0.128	0.027	-0.533	-0.032
Secondary	Higher	-0.232*	0.081	0.004	-0.390	-0.073
*Mean difference is significant at the 0.05 level.						

Table 4.5.32 represents the descriptive statistics of child weight by respondent occupation. Mean weight of the child for mothers with no occupation is around 10.6 kg. For mothers with other occupation and agricultural mothers, average weight of the child is around 10.6 kg and 10.5 kg, respectively.

Table 4.5.32: Descriptive Statistics of Child Weight by Respondent Occupation

Dependent Variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	10.675	0.061	10.556	10.794
Other	10.632	0.099	10.437	10.827
Agriculture	10.501	0.101	10.303	10.700

Table 4.5.33 represents a pairwise comparison of child weight by respondent occupation. Mean difference of child weight between mothers with no occupation and other occupation (M D = 0.043, 95% CI: -0.135 to 0.222, p = 0.635), between mothers with no occupation and agricultural mothers (M D = 0.174, 95% CI: -0.021 to 0.368, p = 0.080) is statistically insignificant. Similarly, mean difference of child weight between mothers' other occupation and agricultural mothers (M D = 0.131, 95% CI: -0.119 to 0.380, p = 0.306) is statistically insignificant.

Table 4.5.33: Pairwise Comparison of Child Weight by Respondent Occupation

Dependent Variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No Occupation	Other	0.043	0.091	0.635	-0.135	0.222
	Agriculture	0.174	0.099	0.08	-0.021	0.368
Other	Agriculture	0.131	0.127	0.306	-0.119	0.380

Table 4.5.34 represents the descriptive statistics of child weight by type of residence. Mean weight of child in urban region is around 10.5 kg and mean weight of child in rural region is around 10.6 kg.

Table 4.5.34: Descriptive Statistics of Child Weight by Type of Residence

Dependent Variable: Child Weight				
Type of residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	10.573	0.076	10.423	10.722
Rural	10.633	0.067	10.502	10.764

Table 4.5.35 represents a pairwise comparison of child weight by type of residence. Mean difference of child weight between urban and rural region (M D = -0.060, 95% CI: -0.186 to 0.065, p = 0.344) is statistically insignificant.

Tables 4.5.35: Pairwise Comparison of Child Weight by Type of Residence

Dependent Variable: Child Weight						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Urban	Rural	-0.060	0.064	0.344	-0.186	0.065

Table 4.5.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.1 kg. In the poorer groups, children's average weight is around 10.3 kg. In the middle groups, children's average weight is around 10.6 kg. Similarly, in richer as well as richest groups, the average weight of children is around 10.8 kg and 11 kg, respectively.

Table 4.5.36: Descriptive Statistics of Child Weight by Wealth Index

Dependent Variable: Child Weight				
Wealth index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.092	0.147	9.804	10.38
Poorer	10.396	0.089	10.221	10.57
Middle	10.620	0.079	10.464	10.78
Richer	10.847	0.078	10.693	11.00
Richest	11.060	0.090	10.884	11.24

Table 4.5.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest group and poorer group (M D = -0.303, 95% CI: -0.603 to - 0.004, $p < 0.05$), between poorest group and middle group (M D = - 0.528, 95% CI: -0.819 to -0.236, $p < 0.05$), between poorest group and richer group (M D = - 0.754, 95% CI: -1.055 to -0.454, $p < 0.05$), and between poorest group and richest group (M D = -0.967, 95% CI: -1.290 to -0.645, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and middle group (M D = - 0.224, 95% CI: -0.400 to -0.049, $p < 0.05$), between poorer group and richer group (M D = -0.451, 95% CI: -0.638 to – 0.264, $p < 0.05$), between poorer and richest group (M D = - 0.664, 95% CI: -0.883 to – 0.445, $p < 0.05$) is statistically significantly. Mean difference of child weight between middle and richer group (M D = - 0.227, 95% CI: -0.377 to – 0.076, $p < 0.05$) and between middle and richest group (M D = -0.440, 95% CI: -0.625 to – 0.255, $p < 0.05$) is statistically significant. Mean difference of child weight between richer and richest group (M D = -0.213, 95% CI: -0.380 to – 0.046, $p < 0.05$) is statistically significant.

Table 4.5.37: Pairwise Comparison of Child Height by Wealth Index

Dependent Variable: Child Weight						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Poorest	Poorer	-0.303*	0.153	0.047	-0.603	-0.004
	Middle	-0.528*	0.149	0.000	-0.819	-0.236
	Richer	-0.754*	0.153	0.000	-1.055	-0.454
	Richest	-0.967*	0.165	0.000	-1.290	-0.645
Poorer	Middle	-0.224*	0.090	0.012	-0.400	-0.049
	Richer	-0.451*	0.095	0.000	-0.638	-0.264
	Richest	-0.664*	0.112	0.000	-0.883	-0.445
Middle	Richer	-0.227*	0.077	0.003	-0.377	-0.076
	Richest	-0.440*	0.094	0.000	-0.625	-0.255
Richer	Richest	-0.213*	0.085	0.012	-0.380	-0.046
*Mean difference is significant at the 0.05 level.						

Table 4.5.38 represents the descriptive statistics of child weight by BMI. The average weight of a child with a normal woman is around 10.5 kg. The average weight of a child in underweight woman is around 10 kg. The average weight of a child in an overweight woman is around 10.7 kg. Similarly, children's average weight in obese woman is around 10.9 kg.

Table 4.5.38: Descriptive Statistics of Child Weight by BMI

Dependent Variable: Child Weight				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	10.555	0.064	10.429	10.68
Underweight	10.144	0.085	9.977	10.312
Overweight	10.748	0.083	10.585	10.911
Obese	10.964	0.123	10.722	11.206

Table 4.5.39 represents a pairwise comparison of child weight by BMI. Mean difference of child weight between normal woman and underweight woman (M D = 0.410, 95% CI: 0.258 to 0.563, $p < 0.05$), between normal woman and overweight woman (M D = - 0.193, 95% CI: -0.339 to -0.047, $p < 0.05$) is statistically significant. Also, mean difference of child weight between normal woman and obese woman (M D = -0.409, 95% CI: -0.641 to -0.177, $p < 0.05$) is statistically significant. Mean difference of child weight between underweight woman and overweight woman (M D = - 0.604, 95% CI: -0.791 to - 0.417, $p < 0.05$) and between underweight woman and obese woman (M D = - 0.820, 95% CI: -1.080 to -0.559, $p < 0.05$) is statistically significant.

Table 4.5.39: Pairwise Comparison of Child Weight by BMI

Dependent Variable: Child Weight						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Normal	Underweight	0.410*	0.078	0.000	0.258	0.563
	Overweight	-0.193*	0.074	0.009	-0.339	-0.047
	Obese	-0.409*	0.118	0.001	-0.641	-0.177
Underweight	Overweight	-0.604*	0.095	0.000	-0.791	-0.417
	Obese	-0.820*	0.133	0.000	-1.08	-0.559
Overweight	Obese	-0.216	0.127	0.088	-0.464	0.033
*Mean difference is significant at the 0.05 level.						

Table 4.5.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 10.8 kg. Similarly, children's average weight in females is around 10.4 kg.

Table 4.5.40: Descriptive Statistics of Child Weight by Child Sex

Dependent Variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	10.805	0.069	10.669	10.941
Female	10.401	0.071	10.262	10.539

Table 4.5.41 represents a pairwise comparison of child weight by Child Sex. Mean difference of child weight between in male children and female children (M D = 0.404, 95% CI: 0.294 to 0.515, $p < 0.05$) is statistically significant.

Table 4.5.41: Pairwise Comparison of Child Weight by Child Sex

Dependent Variable: Child Weight						
Sex of Child	Sex of Child	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Male	Female	0.404*	0.056	0.000	0.294	0.515
*Mean difference is significant at the .05 level.						

4.5.7 Growth Nomogram

Table 4.5.42: Birth-weight categories of under-5 Children by their sociodemographic characteristic in Southern Region of India

Socio-demographic Characteristics		Birthweight								
		< 2000		2000 - 2499		2500 - 2999		3000+		Total
		n1	%	n2	%	n3	%	n4	%	n
Child Age	< 12	244	2.8	1081	12.3	2884	32.8	4587	52.1	8797
	12 - 23	287	3.6	1090	13.6	2517	31.5	4097	51.3	7991
	24 - 35	239	2.8	1039	12.1	2795	32.6	4494	52.5	8567
	36 - 47	259	2.8	1184	12.8	2785	30.2	5005	54.2	9233
	48 - 59	258	3.1	1081	12.9	2535	30.2	4510	53.8	8385
		Chi Square (d.f. = 12) = 49.667, p < 0.001								
Child Sex	Boys	759	3.2	2901	12.4	6815	29.1	12924	55.2	23399
	Girls	745	3.4	2871	13.3	7174	33.1	10861	50.2	21651
		Chi Square (d.f. = 3) = 120.791, p < 0.001								
Birth Order	1	792	3.8	2673	12.8	6869	32.9	10530	50.5	20864
	2	507	2.8	2267	12.7	5421	30.4	9610	54	17806
	3	156	3.2	618	12.8	1341	27.7	2725	56.3	4840
	4 & above	49	3.2	215	13.9	358	23.3	919	59.6	1540
		Chi Square (d.f. = 9) = 152.791, p < 0.001								
BMI	< 18.5	300	3.7	1163	14.5	2683	33.5	3875	48.3	8020
	18.5 -24.9	754	3	3232	12.9	7755	31.1	13234	53	24975
	25.0 - 29.9	321	3.9	958	11.7	2404	29.4	4498	55	8180
	≥ 30	89	3.5	238	9.2	735	28.5	1516	58.8	2578
		Chi Square (d.f. = 9) = 154.988, p < 0.001								
Highest Educational Level	No education	200	3.5	821	14.2	1487	25.8	3257	56.5	5766
	Primary	132	3.1	586	13.9	1254	29.8	2230	53.1	4202
	Secondary	913	3.4	3521	13.2	8592	32.2	13653	51.2	26680
	Higher	258	3.1	844	10	2657	31.6	4644	55.3	8403
		Chi Square (d.f. = 9) = 173.504, p < 0.001								
Respondent Occupation	No Occupation	222	3.4	861	13.2	2122	32.4	3336	51	6541
	Others	27	2.7	123	12.1	296	28.9	576	56.4	1023
	Agriculture	34	3.6	128	13.3	270	28.2	527	54.9	959
	Do not Know	0	0	6	9.2	16	26	40	64.8	62
		Chi Square (d.f. = 9) = 21.576, p = 0.010								
Type of Residence	Urban	572	3	2291	12.2	5854	31.1	10133	53.8	18850
	Rural	932	3.6	3482	13.3	8135	31	13652	52.1	26201
		Chi Square (d.f. = 3) = 25.665, p < 0.001								
Wealth Index	Poorest	96	4.9	256	13.1	579	29.6	1026	52.4	1956
	Poorer	275	3.9	995	14	2111	29.7	3718	52.4	7099
	Middle	420	3.3	1850	14.4	4045	31.5	6530	50.8	12845
	Richer	456	3.3	1784	12.9	4426	32	7169	51.8	13835
	Richest	257	2.8	888	9.5	2828	30.4	5341	57.3	9315
		Chi Square (d.f. = 12) = 201.858, p < 0.001								

Birth-weight by Socio-demographic Characteristics

Table 4.5.42 describes the distribution of under-5 children by their birth-weight categories and socio-demographic characteristics in Southern Region. According to a distribution of under-five children by age and birth weight, 2.8% to 3.6% of children under the age of five had birth weights under 2000 g, 12.1% to 13.6% had birth weights between 2000 g and 2499 g, 30.2% to 32.8% had birth weights between 2500 g and 2999 g, and 51.3% to 54.2% had birth weights of 3000 g or more. It has been shown that there is a significant relationship $\left(\chi^2_{df=12} = 49.667, p < 0.001\right)$ between a child's age and birth weight. In comparison to girls (50.2%), a higher percentage of boys (55.2%) had birthweights of 3000 g & above. A higher percentage of girls had birthweights below 3000 gm. The sex of the children was seen to be highly associated $\left(\chi^2_{df=3} = 120.791, p < 0.001\right)$, just like child age.

It was found that birth order had a significant correlation $\left(\chi^2_{df=9} = 152.791, p < 0.001\right)$ with children's birth weight when birth order was taken into account with under-5 children birth weight. Body Mass Index (BMI) data display that 3.0% to 3.9% of under-5-year-old children with various BMI scores had birth weights under 2000 g, 9.2% to 14.5% had birth weights between 2000 g and 2499 g, 28.5% to 33.5% had birth weights between 2500 g and 2999 g, and 48.3%–58.8% had birth weights of 3000 gm or more. Additionally, for the birth-weight category of 3000 gm & above, the proportion of children increased with increasing BMI scores. The BMI of children under the age of five was shown to be significantly correlated $\left(\chi^2_{df=9} = 154.988, p < 0.001\right)$ with their birthweights.

When the mother's highest level of education is taken into account, 3.1% to 3.5% of babies were born weighing less than 2000 g, 10.0% to 14.2% were born weighing between 2000 g and 2499 g, 25.8% to 32.2% were born weighing between 2500 and 2999 g, and 51.2% to 56.5% were born weighing 3000 g or more. The mother's highest degree of education was significantly correlated $\left(\chi^2_{df=9} = 173.504, p < 0.001\right)$ with the birth weight of the child. When the mother's occupation was considered along with the birth weight of children under the age of 5, it was revealed that there was a significant association $\left(\chi^2_{df=9} = 21.576, p = 0.010\right)$ between the two.

The study also revealed that the two factors of the respondents—their type of location and wealth index—were important in determining their birth weight. Findings showed that 3.0% of urban and 3.6% of rural under-5 children had birth weights < 2000 g, whereas 12.2% of urban and 13.3% of rural under-5 children belonged to the birth weight category between 2000 g and 2499 g. Here, in both the birth-weight groups, the percentage of under-5 children is more in rural areas than in urban areas. But this situation reverses in the birth-weight group 2500 to 2999 gm as well as 3000 gm & above. Types of the place were also significantly associated $\left(\chi^2_{df=3} = 25.665, p < 0.001\right)$ with children’s birth weight. Furthermore, when the wealth index was considered with under-5 children’s birth weight, the analysis revealed that the wealth index had a significant association $\left(\chi^2_{df=12} = 201.858, p < 0.001\right)$ with the children’s birth weight.

4.5.7.1 Growth Estimation of Under-5 Children Using Statistical Model

To estimate the growth curves, all 11 statistical models were fitted to the height and weight data of children under the age of five from the Southern Region of India, independently accounting for the children's ages (months) for each of the four birth-weight groups. Our analysis revealed that, when applying the best-fit model criterion to the height and weight data of under-5-year-old children who fell into the various birth-weight groups, only two statistical models— *Cubic Model* and *Power Model*—showed the best fit, in order to estimate the growth of boys and girls separately. Here, the results of only 2 best-fit models have been shown below (*Tables 4.5.43 and 4.5.44*).

Table 4.5.43 describes the model summary for the height of boys and girls by their birthweight categories. Here, for the height of the boys, considering the Coefficient of Determination (R^2) as the criterion for the best fit, the *Power Model* fits best for the birth-weight group less than 2000 gm $(R^2 = 0.833)$, followed by the group 2000 gm – 2499 gm $(R^2 = 0.798)$. But for the rest of the two groups, *Cubic Model* fits best, i.e., for the birth-weight group 2500 gm – 2999 gm $(R^2 = 0.766)$, followed by group 3000 gm & above $(R^2 = 0.763)$. Forever, for the height of the girls, as per the Coefficient of Determination (R^2), *Power Model* fits best for birth-weight groups less than 2000 gm $(R^2 = 0.798)$. But rest of the three groups, the *Cubic Model* fits best, i.e., for the birth-weight group 2500 – 2999 gm $(R^2 = 0.768)$, followed by group 2000 – 2499 gm $(R^2 = 0.759)$ and group 3000 gm and above $(R^2 = 0.753)$.

Table 4.5.44 describes the model summary for the weight of boys and girls by their birth-weight categories. For the weight of the boys as well as girls, the *Power Model* was the best fit. Further, for boys, considering the Coefficient of Determination

(R^2), this model fitted best for birth-weight less than 2000 - 2499 gm ($R^2 = 0.791$), followed by a group of less than 2000 gm ($R^2 = 0.7581$), group 2500 – 2999 gm ($R^2 = 0.735$), and birth-weight group 3000 gm and above ($R^2 = 0.709$). For estimating the weight of girls, the Power Model fitted best for the birth-weight group less than 2000 gm ($R^2 = 0.786$), followed by the group 2500 – 2999 gm ($R^2 = 0.755$), group 2000 – 2499 gm ($R^2 = 0.723$), and for the birth-weight group 30000 gm and above ($R^2 = 0.713$).

Table 4.5.43: Model's summary for Height of Boys & Girls by their Birthweight categories (South Region)

Birthweight	Model	R^2	Constant	d.f.		f	b_1	b_2	b_3
				Regression	Residuals				
Boys									
< 2000	Power	0.833	41.242	1	329	1642.0	0.219		
2000 - 2499	Power	0.798	46.115	1	1469	5810.7	0.189		
2500 - 2999	Cubic	0.766	56.366	3	3693	4023.0	1.644	-0.026	0.0001
3000 +	Cubic	0.763	57.305	3	6447	6935.0	1.614	-0.026	0.0001
Girls									
< 2000	Power	0.798	44.718	1	345	1365.7	0.191		
2000 - 2499	Cubic	0.759	53.944	3	1564	1646.2	1.727	-0.029	0.0002
2500 - 2999	Cubic	0.768	54.720	3	3946	4350.4	1.693	-0.027	0.0002
3000 +	Cubic	0.753	55.856	3	5499	5592.5	1.681	-0.028	0.0002

Table 4.5.44: Model's summary for Weight of Boys & Girls by Birthweight categories (South Region)

Birthweight	Model	R^2	Constant	d.f.		f	b_1
Boys				Regression	Residuals		
< 2000	Power	0.781	2380.975	1	331	1181.586	0.444
2000 - 2499	Power	0.791	3298.763	1	1475	5578.476	0.356
2500 - 2999	Power	0.735	3578.184	1	3703	10269.255	0.338
3000 +	Power	0.709	3850.194	1	6464	15785.694	0.325
Girls							
< 2000	Power	0.786	2528.182	1	346	1268.842	0.412
2000 - 2499	Power	0.723	3169.492	1	1568	4095.252	0.354
2500 - 2999	Power	0.755	3257.764	1	3956	12202.959	0.356
3000 +	Power	0.713	3566.888	1	5511	13706.928	0.336

4.5.7.2 Height and Weight Curves for boys and girls in Southern Region of India

We used either Cubic or Power Models, depending on which one fits best, to calculate growth values for boys and girls individually, based on the mean height and weight of children under the age of 5, for ages ranging from 1 to 59 months. As a result, mean height and weight curves were created individually for the two sexes, considering the four birth-weight groups. For all four birth-weight groups, the estimated mean height and weight curves for boys are shown in *Figures 4.5.5 (a) – (d)*. Similar estimated mean height and weight curves for girls for all four birth weight groups are displayed in *Figures 4.5.6 (a) - (d).* In addition to showing curves for estimated mean height and mean weight, the graphs also show curves for 95% upper and lower bounds. Thus, using curves of Figures 4.5.5 (a)–(d) and Figure 4.5.6 (a)–(d), it is possible to derive not only the expected average growth values of under-5 children in terms of their mean height and mean weight for their ages but also their 95% upper and lower bounds in each case.

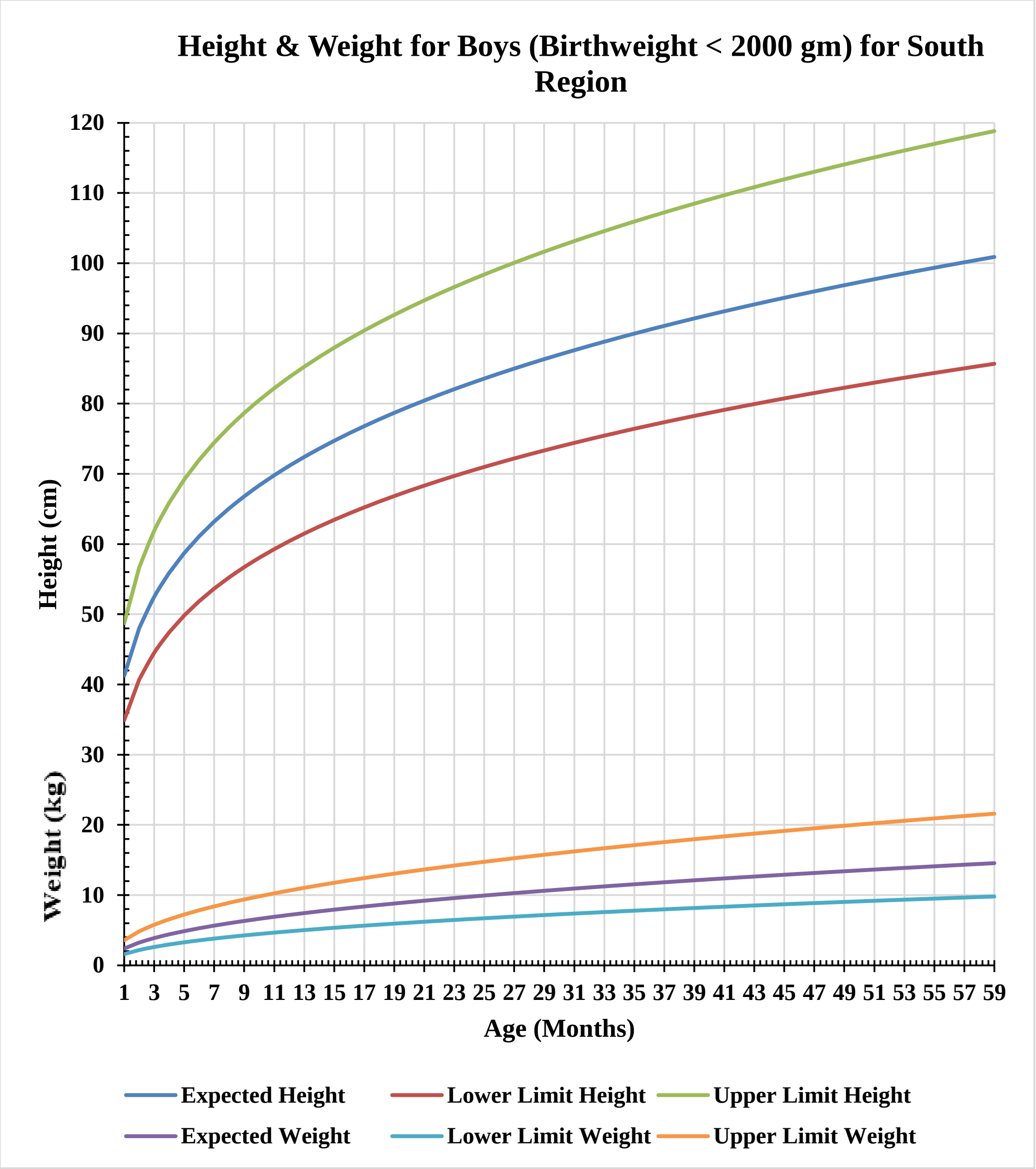


Figure 4.5.5(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Boys of South Region (India), Using Power Model

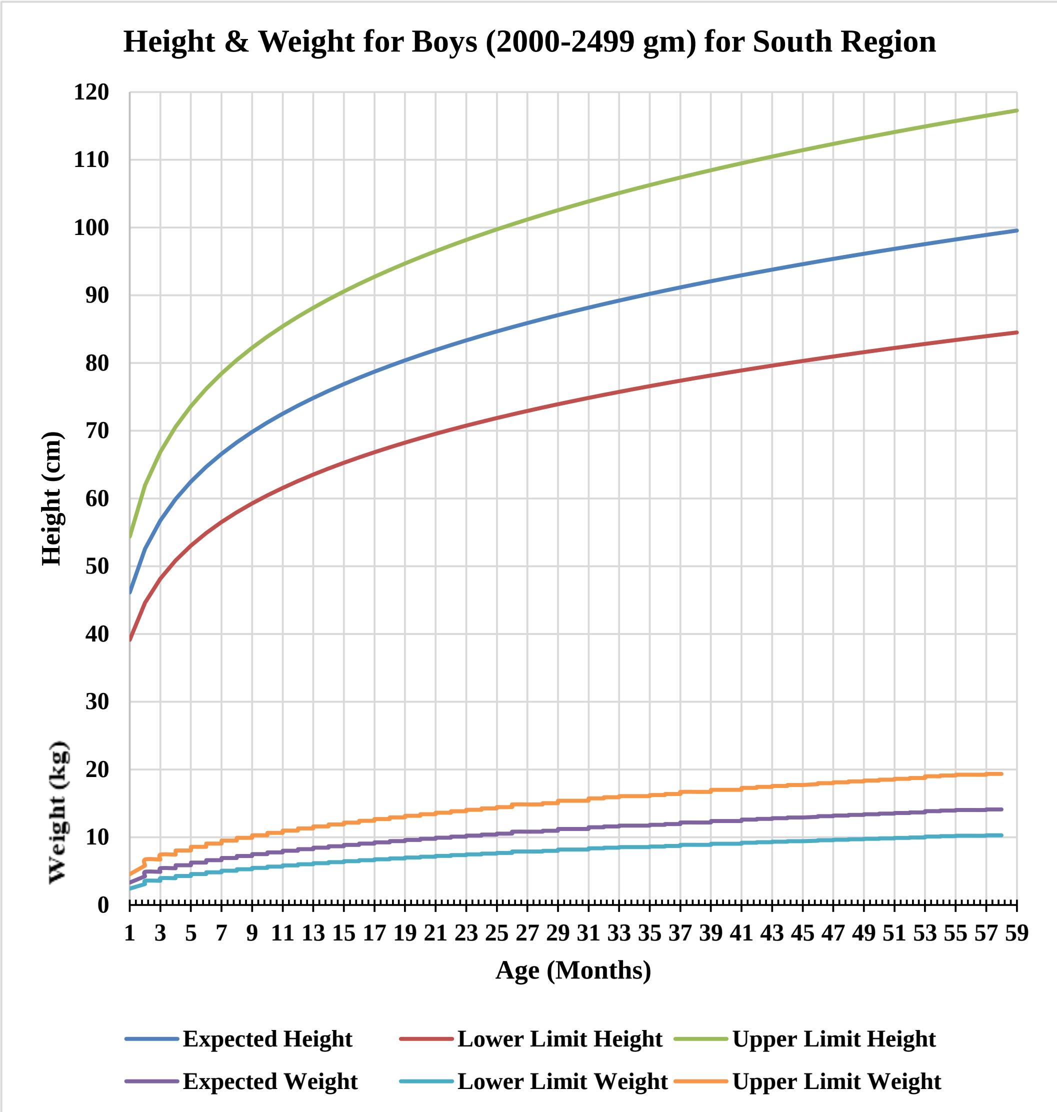
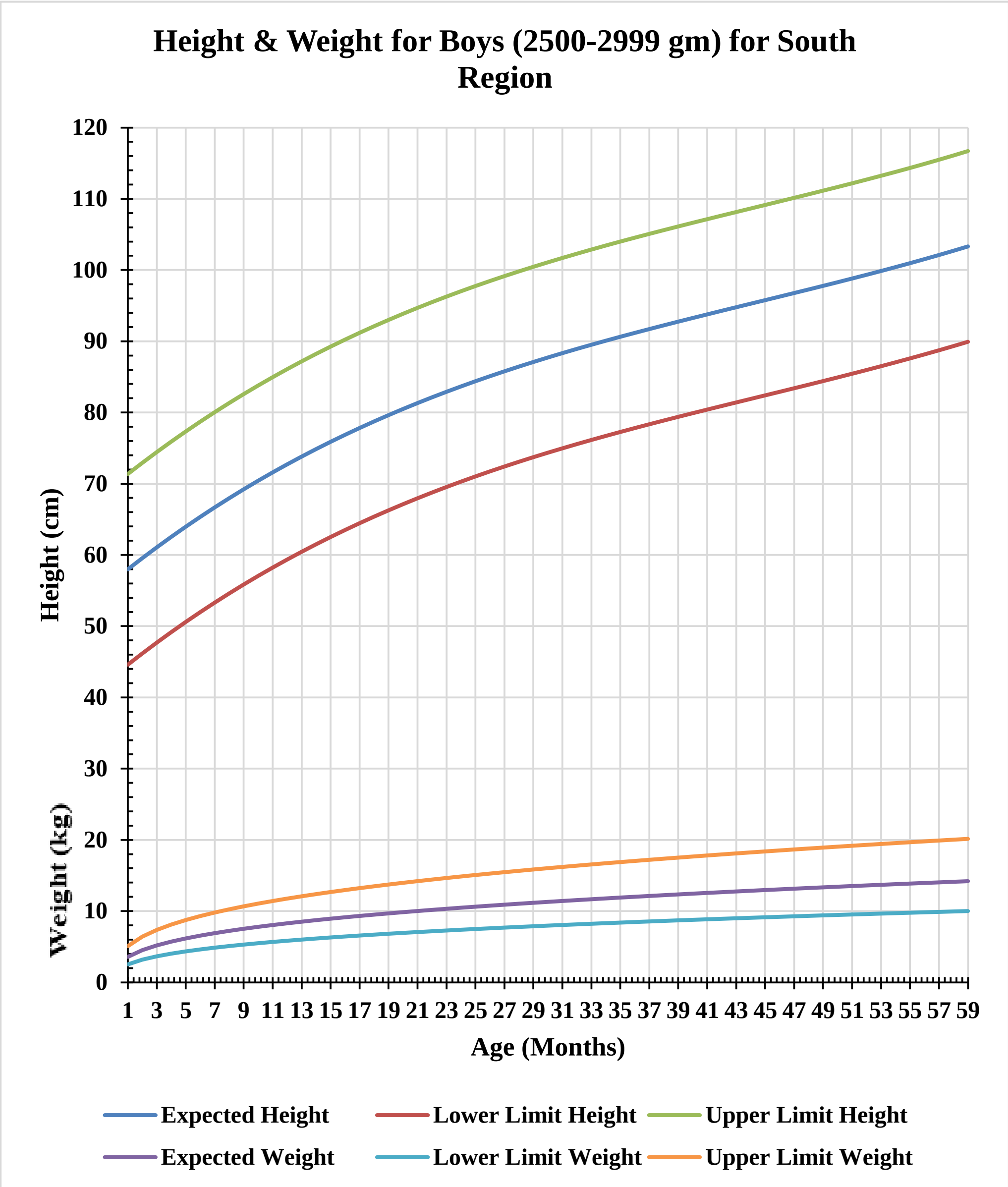


Figure 4.5.5(*b*): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Boys of South Region (India), Using Power Model



$\boldsymbol{Figure}$ $4.5.5(c)$: NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Boys of South Region (India), Using Cubic and Power Model, respectively

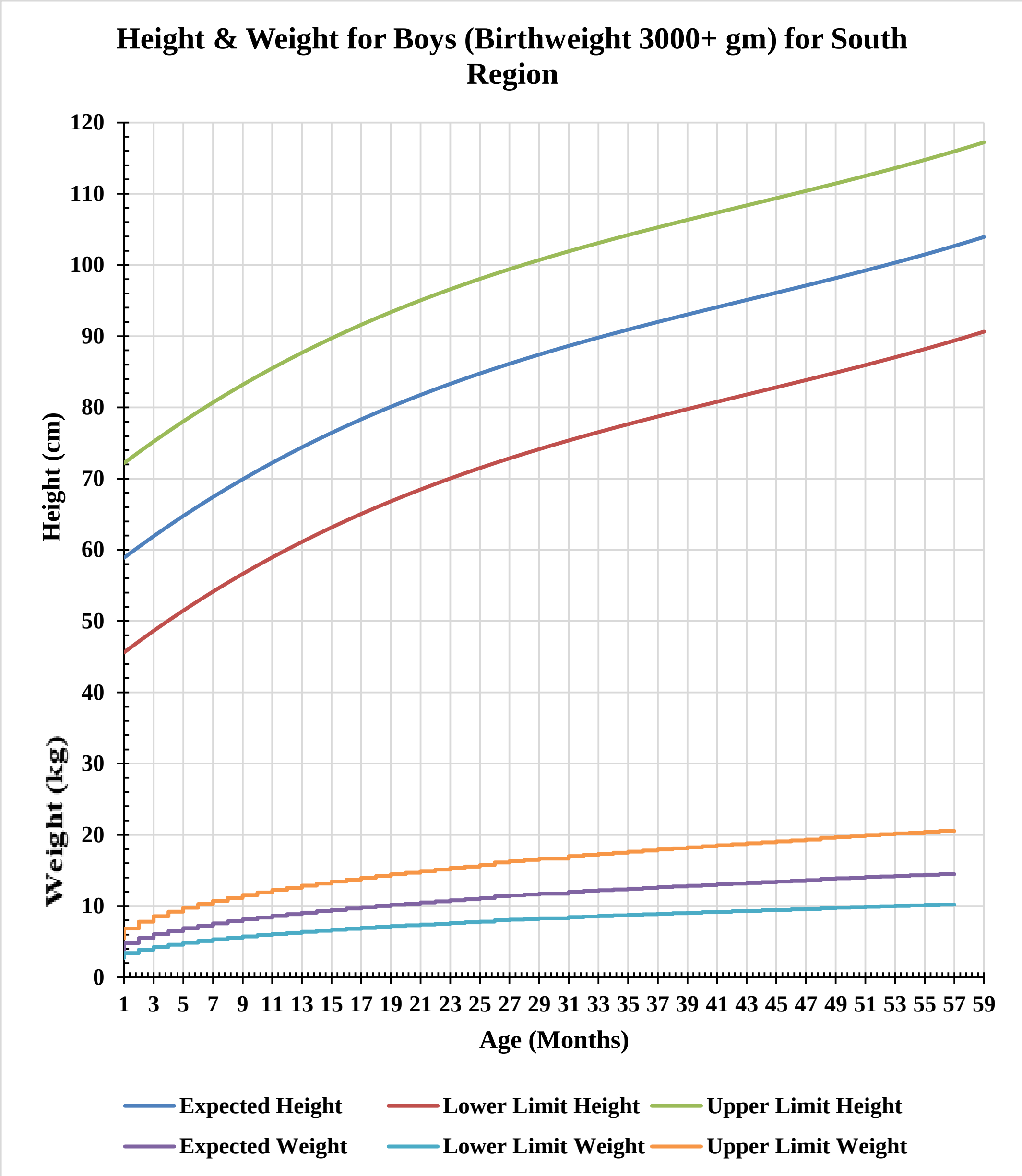


Figure 4.5.5 (*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Boys of South Region (India), Using Cubic and Power Model, respectively

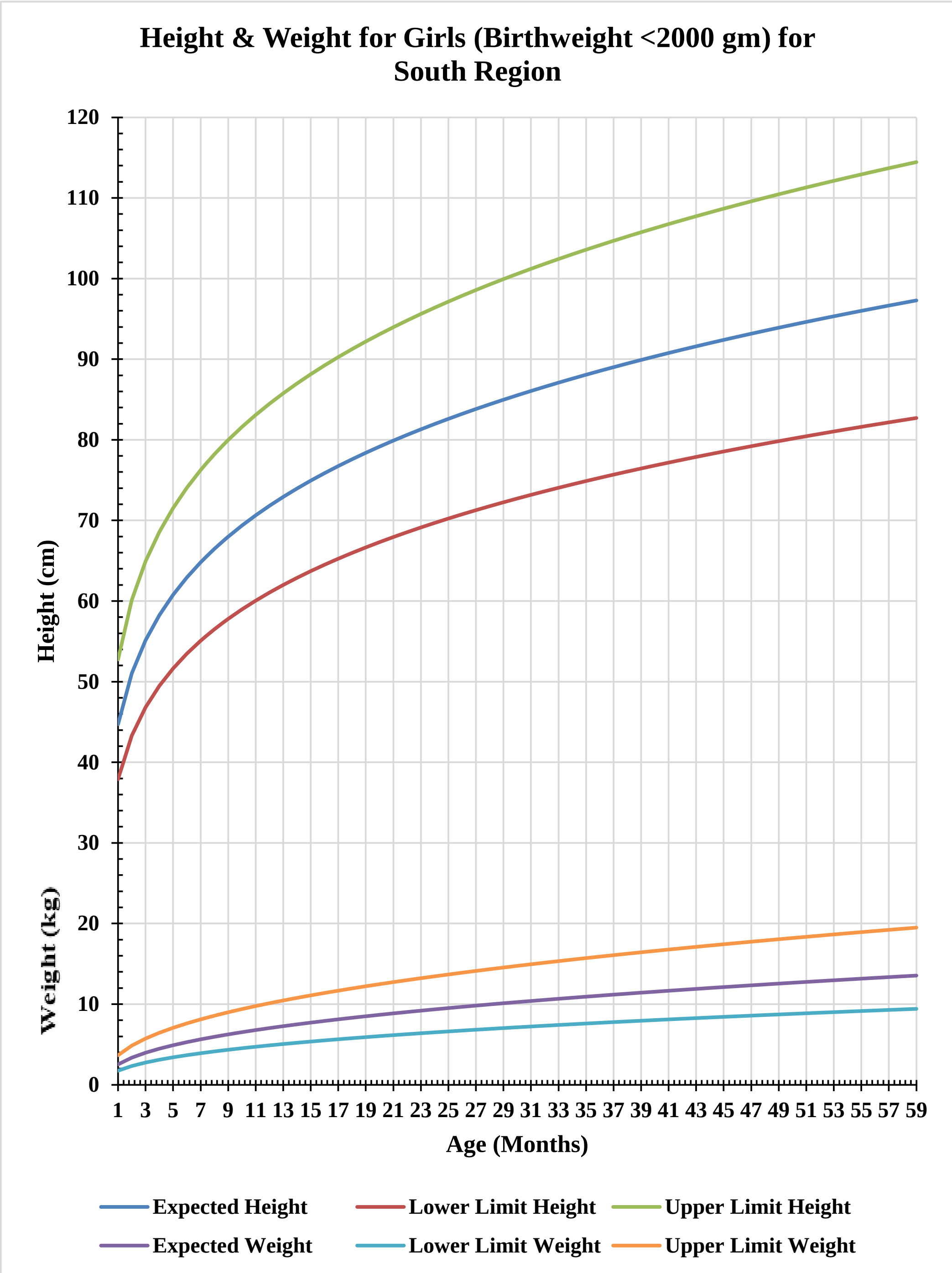


Figure 4.5.6 (*a*): NFHS-4 (Birth-weight < 2000 gm): Estimated Height & Weight Curves for Girls of South Region (India), Using Power Model

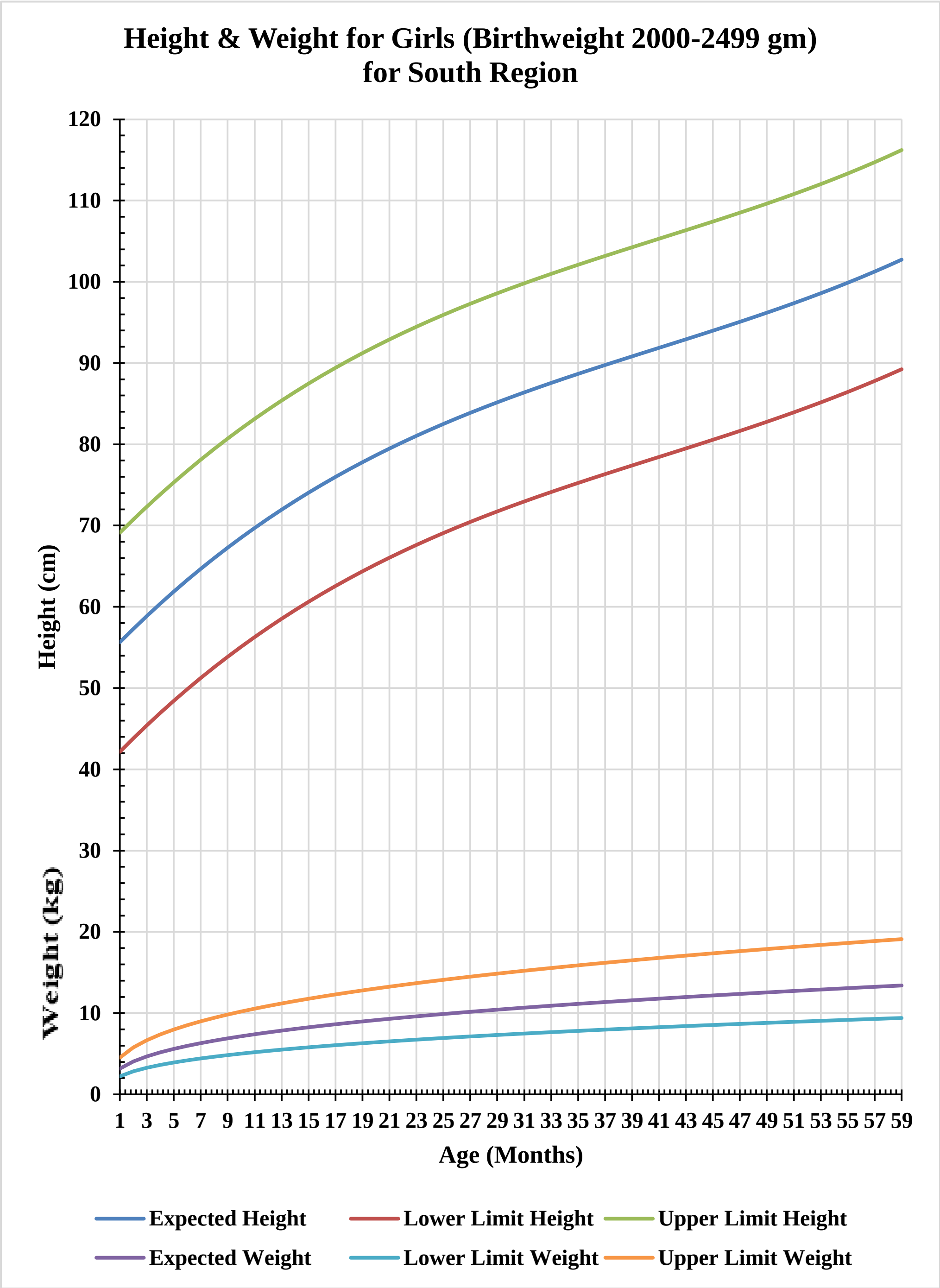
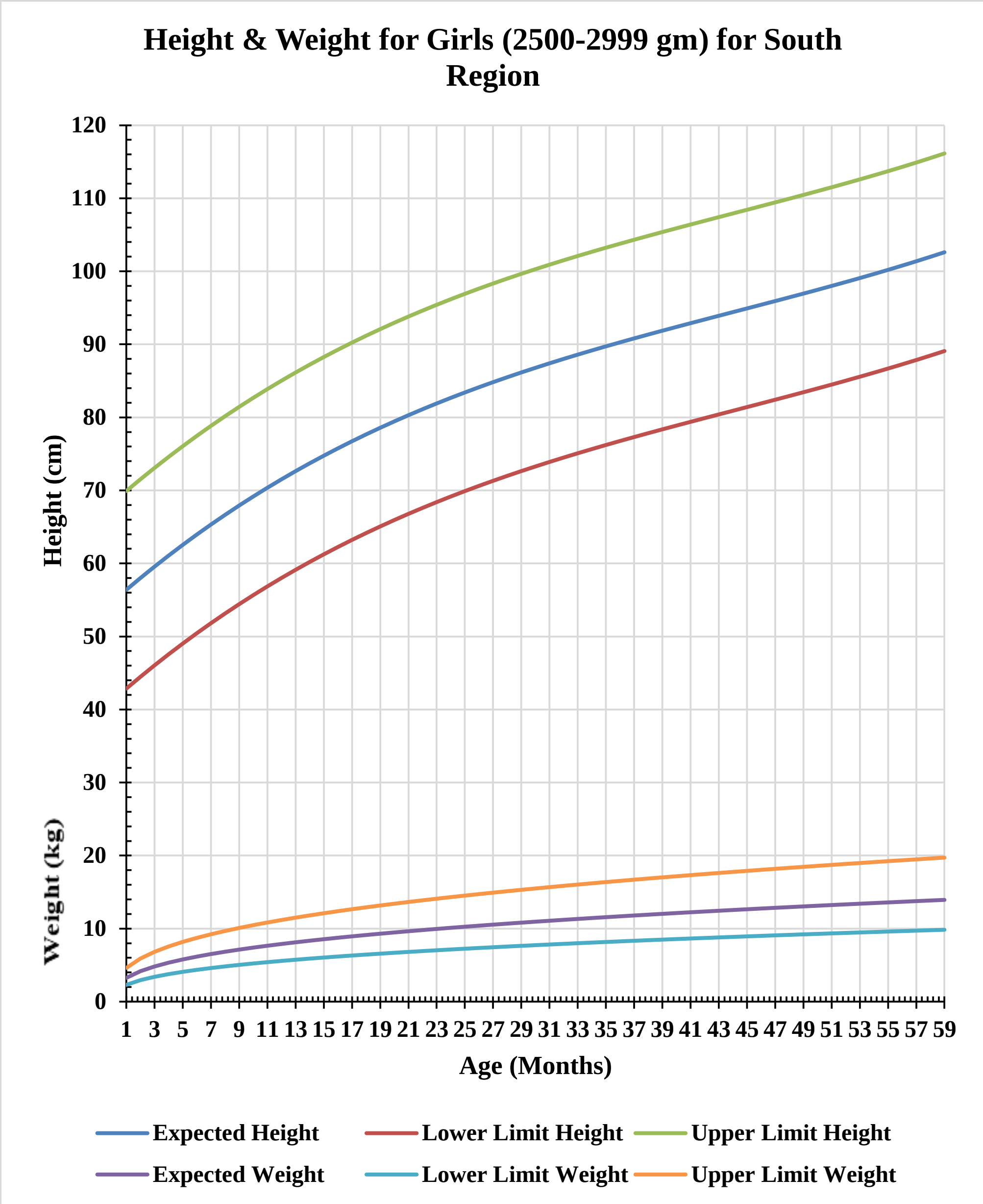
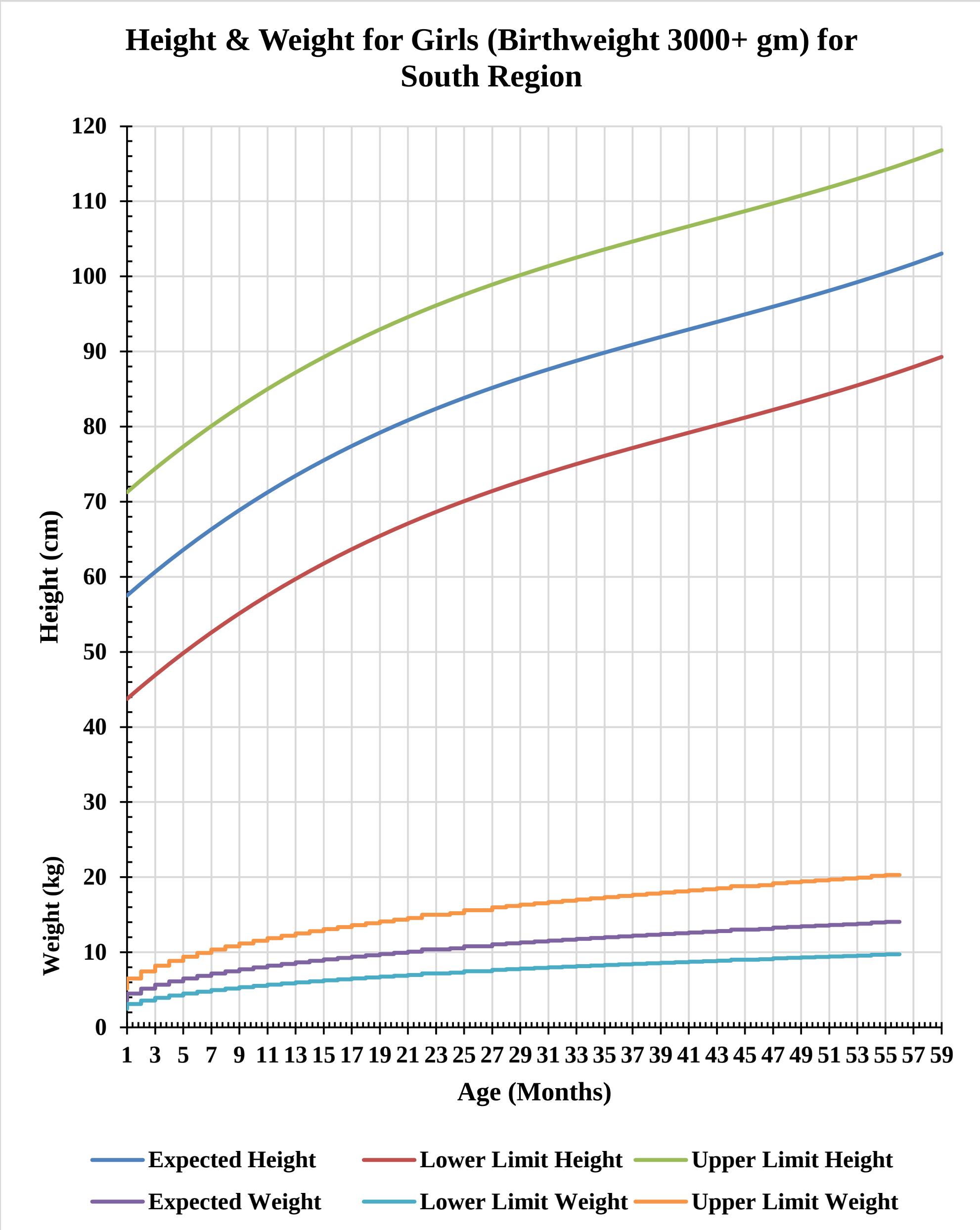


Figure 4.5.6 (*b*): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Girls of South Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.5.6 (c): NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Girls of South Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.5.6 (d): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Girls of South Region (India), Using Cubic and Power Model, respectively

4.6 Western Region

This Region consists of 3 States & 2 UTs, namely – Dadra & Nagar Haveli, Daman & Diu, Goa, Gujarat & Maharashtra.

4.6.1 Status of Under-Nutrition

Table 4.6.1: Prevalence rates (%) of stunting, wasting, and underweight.

State/U.T.	Stunting	Wasting	Underweight
Western Region	**31.6**	**22.3**	**32.8**
Dadra &Nagar Haveli	41.7	27.6	38.8
Daman & Diu	23.4	24.1	26.7
Goa	20.1	21.9	23.8
Gujarat	38.5	26.4	39.3
Maharashtra	34.4	25.6	36.0

Figure 4.6.1: Prevalence rates (%) of stunting, wasting, and underweight.

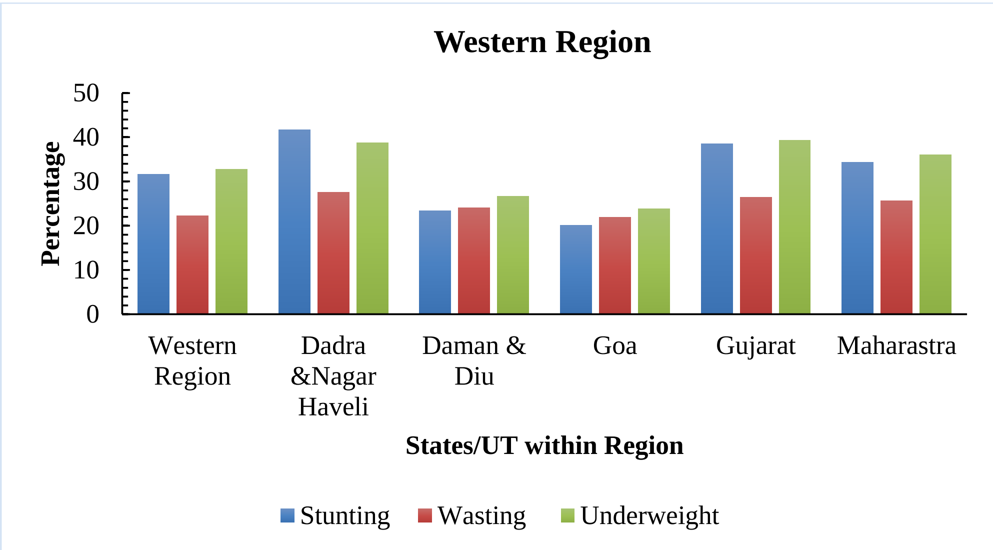


Table 4.6.1 and Figure 4.6.1 present the prevalence rates of stunting, wasting, and underweight in the Western Region. Stunting exhibited variations ranging from 41.7% in Dadar & Nagar Haveli to 20.1% in Goa. Wasting reached its peak at 27.6% in Dadar & Nagar Haveli, while Goa recorded the lowest wasting rate at 21.9%. The prevalence of underweight was at its highest (39.3%) in Gujarat and lowest (23.8%) in Goa.

4.6.2 Stunting

Table 4.6.2: - Odds Ratio of Stunting in Under-5 Children by socio-demographic variables in the Western Region of India

Socio-demographic Variables	p-value	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	2.80	2.48	3.14
24 - 35	0.000	2.71	2.41	3.04
36 - 47	0.000	2.79	2.49	3.12
48 - 59	0.000	2.39	2.13	2.68
Child Sex				
Female *(Ref)*		1.00		
Male	0.001	1.12	1.05	1.20
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.31	1.98	2.70
Poorer	0.000	2.12	1.85	2.42
Middle	0.000	1.79	1.58	2.03
Richer	0.000	1.29	1.15	1.46
Highest Educational Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.78	1.50	2.12
Primary	0.000	1.78	1.50	2.12
Secondary	0.000	1.53	1.32	1.76
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.576	1.02	0.94	1.11
Birth Order				
1 *(Ref)*		1.00		
2	0.326	1.04	0.96	1.13
3	0.317	1.06	0.95	1.17
4 & above	0.001	1.24	1.09	1.41
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.22	1.13	1.31
Overweight	0.000	0.79	0.70	0.89
Obese	0.064	0.83	0.67	1.01

Table 4.6.2 represents the odds ratio of Stunting in Under-5 Children by socio-demographic variables in the Western Region of India. Stunted children are 2.8 times higher in the aged group 12 – 23 months (OR: 2.80; 95% CI: 2.48 – 3.14; $p < 0.001$) as compared to children below 12 months. As compared to children under the age of 12 months, the odds of stunting were 2.7 times higher in the age groups of 24 to 35 months (OR: 2.71; 95% CI: 2.41 – 3.04; $p < 0.001$) and 36 to 47 months (OR: 2.79; 95% CI: 2.49 – 3.12; $p < 0.001$). As compared to children under 12 months, the odds of stunted children were 2.3 times higher in the 48 to 59-month age group months (OR: 2.39; 95% CI: 2.13 – 2.68; $p < 0.001$). As compared to female children, male children (OR: 1.12; 95% CI: 1.05 – 1.20; $p < 0.001$) had odds of being stunted that were significantly higher.

When compared to the Richest Group, the odds of stunted children were 2.3 times higher in the Poorest Group (OR: 2.31; 95% CI: 1.98 – 2.70; $p < 0.001$). As compared to the Richest Group, the odds of stunted children were 2.1 times higher in the Poorer Group (OR: 2.12; 95% CI: 1.85 – 2.42; $p < 0.001$). As compared to the Richest Group, the Middle Group (OR: 1.79; 95% CI: 1.58 – 2.03; $p < 0.001$) had 1.7 times more stunted children. As compared to the Richest Group, the odds of stunted children more 1.2 times higher in the Richer group (OR: 1.29; 95% CI: 1.15 – 1.46; $p < 0.001$).

Women with no education (OR: 1.78; 95% CI: 1.50 – 2.12; $p < 0.001$) as well as primary education (OR: 1.78; 95% CI: 1.50 – 2.12; $p < 0.001$) experienced 1.7 times higher odds of being stunted children as compared to women with a Higher Education level. As compared to women with higher education levels, women with secondary education (OR: 1.53; 95% CI: 1.32 – 1.76; $p < 0.001$) had a 1.5 times greater chance of having stunted children. As compared to urban areas, there were significantly higher odds of having stunted children in rural areas (OR: 1.02; 95% CI: 0.94 – 1.11; $p < 0.001$).

As compared to the first birth order, children born in the second birth order (OR: 1.04; 95% CI: 0.96 – 1.13; $p = 0.326$) had significantly higher odds of being stunted. Children born in the third birth order (OR: 1.06; 95% CI: 0.95 – 1.17; $p = 0.317$) had significantly greater odds of being stunted than those born in the first birth order. The likelihood of stunting is not significantly different for children born in the second and third birth order compared to those born in the first birth order. Children born in birth order 4 and above (OR: 1.24; 95% CI: 1.09 – 1.41; $p < 0.001$) had 1.2 times higher odds of being stunted than children born in the first birth order.

As compared to normal mothers, those who were underweight mothers had 1.2 times greater odds of having children who were stunted. Overweight mothers had 21% lesser odds of having stunted children than normal mothers. Obese mothers had 17% lower odds of having children who were stunted than normal mothers.

Diagnostic Evaluation of Logistic Regression

Table 4.6.3 shows the sensitivity and specificity of the model at 62%. However, depending on the demands of the research and the requirement for diagnostic research, sensitivity and specificity might be altered. The area under the curve is 0.662 (95% CI: 0.653 – 0.671) (Figure 4.6.2).

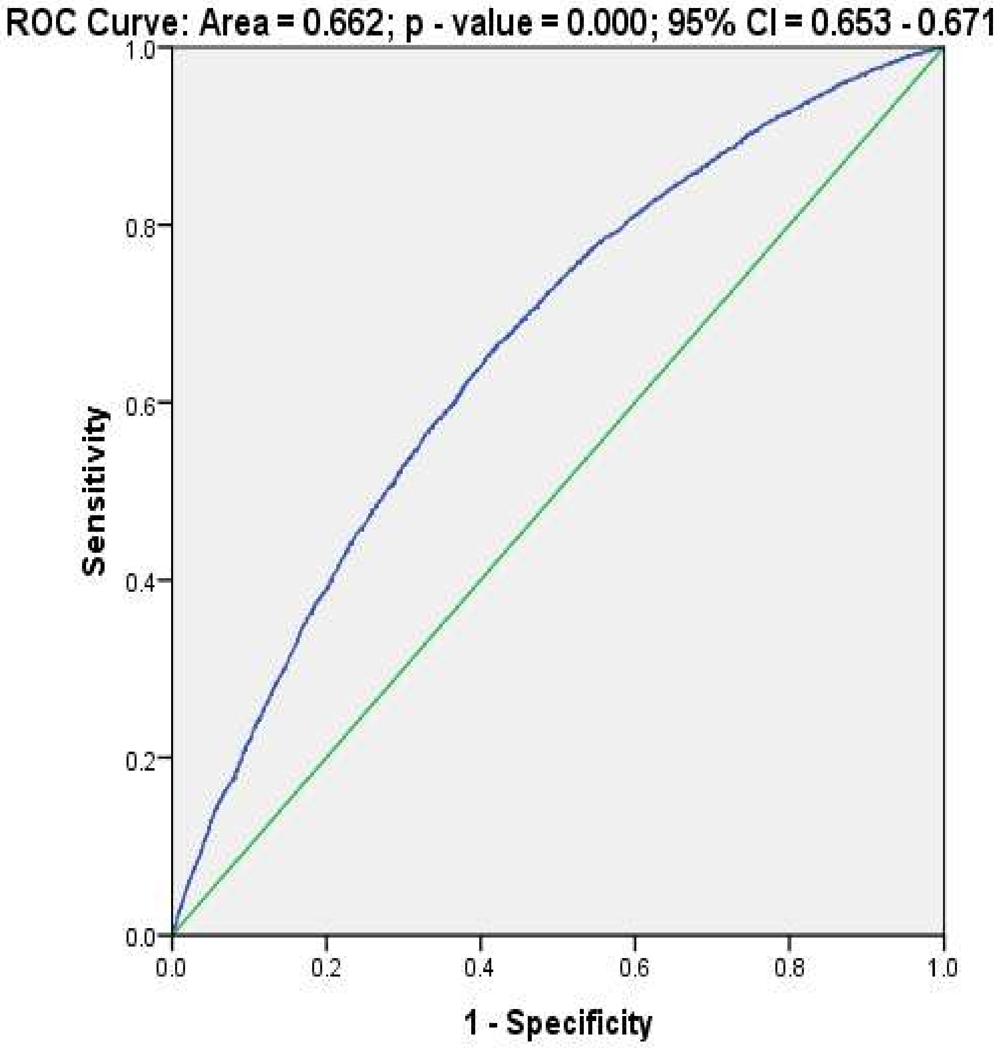


Figure. 4.6.2: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Stunting in the Western Region of India

Table 4.6.3: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	Sensitivity	Specificity
0.1752104	0.970	0.104
0.1772331	0.969	0.106
0.1920570	0.959	0.132
0.2049045	0.949	0.151
0.2123427	0.939	0.175
0.2246431	0.928	0.197
0.2622419	0.878	0.290
0.2680810	0.869	0.304
0.2738412	0.859	0.320
0.2813721	0.849	0.339
0.2870413	0.839	0.356
0.2916553	0.829	0.373
0.3168997	0.779	0.447
0.3221411	0.769	0.461
0.3275033	0.759	0.472
0.3332554	0.749	0.482
0.3377306	0.738	0.496
0.3416827	0.729	0.505
0.3644461	0.679	0.558
0.3705839	0.669	0.572
0.3751921	0.659	0.583
0.3783450	0.649	0.593
0.3819763	0.639	0.601
0.3919815	**0.620**	**0.620**
0.4342840	0.521	0.705
0.4455290	0.503	0.719
0.4892214	0.350	0.827
0.4928853	0.336	0.836
0.5340337	0.182	0.918
0.5397648	0.159	0.933

4.6.3 Wasting

Table 4.6.4: - Odds Ratio of Wasting in Under-5 Children by socio-demographic variables in Western Region of India

Socio - demographic Variables	p - values	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1		
12 - 23	0.000	0.72	0.64	0.81
24 - 35	0.000	0.70	0.63	0.79
36 - 47	0.000	0.67	0.60	0.75
48 - 59	0.000	0.63	0.56	0.71
Child Sex				
Female *(Ref)*		1		
Male	0.002	1.13	1.05	1.21
Wealth Index				
Richest *(Ref)*		1		
Poorest	0.000	1.59	1.35	1.87
Poorer	0.000	1.43	1.24	1.66
Middle	0.031	1.16	1.01	1.33
Richer	0.223	1.08	0.95	1.23
Highest Education Level				
Higher *(Ref)*		1		
No Education	0.960	1.01	0.84	1.20
Primary	0.469	0.94	0.79	1.12
Secondary	0.960	1.00	0.87	1.16
Type of Residence				
Urban *(Ref)*		1		
Rural	0.701	0.98	0.90	1.08
Birth Order				
1 *(Ref)*		1		
2	0.246	1.05	0.97	1.14
3	0.871	1.01	0.90	1.13
4 & above	0.179	1.10	0.96	1.26
BMI				
Normal *(Ref)*		1		
Underweight	0.000	1.29	1.19	1.40
Overweight	0.000	0.77	0.68	0.87
Obese	0.000	0.59	0.46	0.75

Table 4.6.4 represents the odds ratio of Wasting in Under-5 Children by socio-demographic variables in the Western Region of India. Children between the ages 12 – 23 months (OR: 0.72; 95% CI: 0.64 – 0.81; $p < 0.001$) had a 28% lower chance of being wasted children compared to children below 12 months. Children between the ages of 24 and 35 months (OR: 0.70; 95% CI: 0.63 – 0.79; $p < 0.001$) had a 30% lower risk of being wasted children than children below 12 months. Comparing children under the age of 12 months to children between the ages of 36 and 47 months (OR: 0.67; 95% CI: 0.60 – 0.75; $p < 0.001$), the chance of being wasted was 33% lower. Compared to children under the age of 12 months, children aged 48 to 59 months (OR: 0.63; 95% CI: 0.56 – 0.71; $p < 0.001$) had a 37% lower chance of being wasted. In comparison to female children, male children (OR: 1.13; 95% CI: 1.05 – 1.21; $p = 0.002$) had a 1.1 times higher risk of being wasted.

In comparison to the richest group, the poorest group (OR: 1.59; 95% CI: 1.35 – 1.87; $p < 0.001$) had a 1.5 times greater likelihood of having wasted children. When compared to the richest group, the poorer group's (OR: 1.43; 95% CI: 1.24 – 1.66; $p < 0.001$) chance of having wasted children was 1.4 times higher. The chance of having wasted children was 1.1 times higher in the middle group (OR: 1.16; 95% CI: 1.01 – 1.33; $p = 0.031$) compared to the richest group. The chance of having wasted children was one time higher in the richer group (OR: 1.08; 95% CI: 0.95 – 1.23; $p = 0.223$) when compared to the richest group. There is no significant difference in the likelihood of wasted children in the richer group as compared to the richest group.

In comparison to mothers with higher education levels, mothers with no education (OR: 1.01; 95% CI: 0.84 – 1.20; $p = 0.960$) as well as secondary education (OR: 1.00; 95% CI: 0.87 – 1.16; $p = 0.960$) had significantly higher odds of having wasted children. In comparison to mothers with higher levels of education, mothers with primary education (OR: 0.94; 95% CI: 0.79 – 1.12; p = 0.469) had 6% lower odds of having wasted children. There is no significant difference in the likelihood of wasted children in mothers with no education, primary education as well as secondary education as compared to mothers with higher education levels. Compared to urban areas, rural areas (OR: 0.98; 95% CI: 0.90 – 1.08; p = 0.701) had 2% lower odds of being wasted children. There is no significant difference in the likelihood of wasted children in rural areas as compared to urban areas.

In comparison to the first birth order, the second birth order (OR: 1.05; 95% CI: 0.97 – 1.14; p = 0.246) had significantly higher odds of having wasted children. In comparison to the first birth order, the third birth order (OR: 1.01; 95% CI: 0.90 – 1.13; p = 0.871) also had significantly higher odds of having wasted children. When compared to the first birth order, children in birth order 4 and upwards (OR: 1.10; 95% CI: 0.96 – 1.26; p = 0.179) had a 1.1 times higher chance of being wasted. There is no significant difference in the likelihood of wasted children in the second, third, fourth, and above birth order as compared to the first birth order.

Underweight mothers (OR: 1.29; 95% CI: 1.19 – 1.40; $p < 0.001$) had 1.2 times higher odds of being wasted children as compared to normal mothers. Overweight mothers (OR: 0.77; 95% CI: 0.68 – 0.87; $p < 0.001$) had 23% lower odds of being wasted children as compared to normal mothers. Obese mothers (OR: 0.59; 95% CI: 0.46 – 0.75; $p < 0.001$) had a 41% lower chance of being wasted children as compared to normal mothers.

Diagnostic Evaluation of Logistic Regression

Table 4.6.5 shows the model's sensitivity and specificity at 56.7%. However, depending on the needs of the study and the demand for diagnostic research, sensitivity and specificity may alter. Area under the ROC curve is 0.592 (95% CI: 0.582 – 0.602) (Figure 4.6.3).

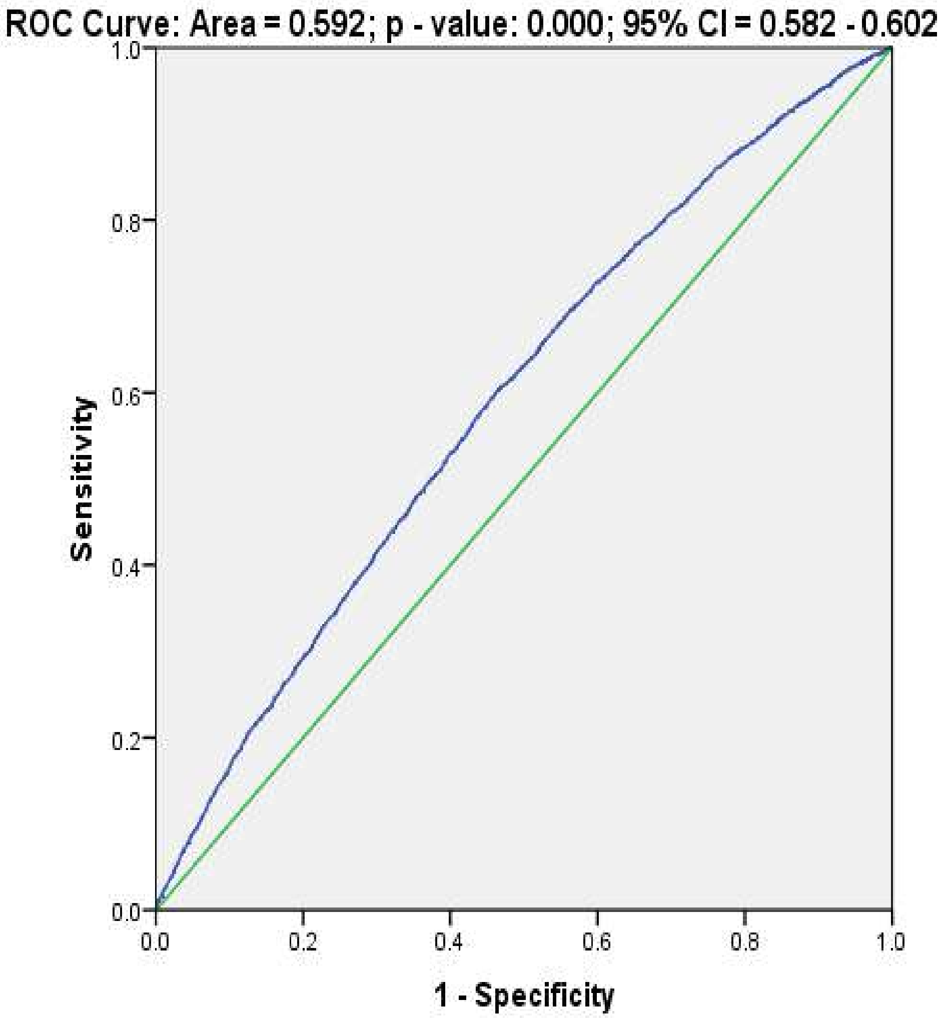


Figure 4.6.3: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Wasting in the Western Region of India

Table 4.6.5: - Sensitivity & Specificity of the model at a different cut of points

Probability (≥)	Sensitivity	Specificity
0.1720163	0.970	0.068
0.1721167	0.969	0.069
0.1758797	0.959	0.082
0.1824569	0.949	0.100
0.1877263	0.939	0.115
0.1927862	0.928	0.134
0.2079695	0.879	0.209
0.2116544	0.869	0.224
0.2135687	0.858	0.241
0.2145889	0.849	0.249
0.2158268	0.837	0.263
0.2165902	0.828	0.273
0.2311439	0.749	0.371
0.2344087	0.729	0.398
0.2344550	0.729	0.399
0.2465636	0.659	0.472
0.2493509	0.650	0.481
0.2494389	0.648	0.482
0.2509815	0.639	0.492
0.2530874	0.628	0.503
0.2547413	0.619	0.513
0.2610310	0.599	0.538
0.2626036	0.589	0.548
0.2634326	0.579	0.557
0.2646167	**0.567**	**0.567**
0.2647924	0.565	0.569
0.2735518	0.518	0.609
0.2760492	0.499	0.627
0.2969644	0.361	0.745
0.3003118	0.345	0.757
0.3145236	0.278	0.812
0.3215946	0.237	0.843
0.3481872	0.143	0.916
0.3501693	0.137	0.920

4.6.4 Underweight

Table 4.6.6: - Odds ratio of Underweight in Under-5 Children by socio-demographic variables in Western Region of India

Socio - demographic Variables	p - values	OR	95% C.I. for OR	
			Lower Limit	Upper Limit
Child Age (Months)				
< 12 *(Ref)*		1.00		
12 - 23	0.000	1.53	1.36	1.71
24 - 35	0.000	2.00	1.79	2.23
36 - 47	0.000	2.16	1.94	2.41
48 - 59	0.000	2.11	1.89	2.36
Child Sex				
Female *(Ref)*		1.00		
Male	0.005	1.10	1.03	1.18
Wealth Index				
Richest *(Ref)*		1.00		
Poorest	0.000	2.41	2.07	2.82
Poorer	0.000	2.17	1.89	2.48
Middle	0.000	1.64	1.45	1.86
Richer	0.001	1.23	1.09	1.38
Highest Education Level				
Higher *(Ref)*		1.00		
No Education	0.000	1.58	1.33	1.88
Primary	0.000	1.57	1.32	1.86
Secondary	0.000	1.43	1.24	1.65
Type of Residence				
Urban *(Ref)*		1.00		
Rural	0.772	1.01	0.93	1.10
Birth Order				
1 *(Ref)*		1.00		
2	0.009	1.11	1.03	1.20
3	0.190	1.07	0.97	1.19
4 & above	0.000	1.26	1.11	1.43
BMI				
Normal *(Ref)*		1.00		
Underweight	0.000	1.53	1.419	1.653
Overweight	0.000	0.65	0.579	0.735
Obese	0.000	0.55	0.443	0.688

Table 4.6.6 represents the odds ratio of Underweight in Under-5 Children by socio-demographic variables in the Western Region of India. In comparison to children less than 12 months, the prevalence of underweight children was 1.5 times greater in the age group 12–23 months (OR: 1.53; 95% CI: 1.36 – 1.71; $p < 0.001$). When compared to children less than 12 months in age, the prevalence of underweight children was 2 times greater in the 24 to 35 age group (OR: 2.00; 95% CI: 1.79 – 2.23; $p < 0.001$). The odds of underweight children were 2.1 times higher in the age groups of 36 to 47 months (OR: 2.16; 95% CI: 1.94 – 2.41; $p < 0.001$) and 48 to 59 months (OR: 2.11; 95% CI: 1.89 – 2.36; $p < 0.001$) compared to children less than 12 months. Male children (OR: 1.10; 95% CI: 1.03 – 1.18; $p = 0.005$) had a 1.1 times higher chance of being underweight than female children.

When compared to the richest group, the poorest group's (OR: 2.41; 95% CI: 2.07 – 2.82; $p < 0.001$) risks of having underweight children were 2.4 times higher. When compared to the richest group, the poorer group's (OR: 2.17; 95% CI: 1.89 – 2.48; $p < 0.001$) risks of having underweight children were 2.1 times higher. In comparison to the richest group, the middle group (OR: 1.64; 95% CI: 1.45 – 1.86; $p < 0.001$) had 1.6 times the chance of having underweight children. In comparison to the richest group, the richer group (OR: 1.23; 95% CI: 1.09 – 1.38; $p < 0.001$) had a 1.2 times higher chance of having underweight children.

Mothers with no education (OR: 1.58; 95% CI: 1.33 – 1.88; $p < 0.001$) as well as primary education (OR: 1.57; 95% CI: 1.32 – 1.86; $p < 0.001$) had a 1.5 times greater chance of having underweight children than mothers with higher levels of education. When compared to moms with higher levels of education, mothers with secondary education (OR: 1.43; 95% CI: 1.24 – 1.65; $p < 0.001$) had a 1.4 times higher chance of producing underweight children. In comparison to urban areas, children's chances of being underweight were 1 time higher in rural areas (OR: 1.01; 95% CI: 0.93 – 1.10; p = 0.772). There is no significant difference in the likelihood of underweight children in rural areas compared to urban areas.

In comparison to the first birth order, the second birth order (OR: 1.11; 95% CI: 1.03 – 1.20; p = 0.009) had a 1.1 times greater chance of having underweight children. In comparison to the first birth order, the third birth order (OR: 1.07; 95% CI: 0.97 – 1.19; p = 0.190) had a 1-time higher chance of having underweight children. There is no significant difference in the likelihood of underweight children in the third birth order compared to the first birth order. When compared to the first birth order, children in birth order 4 and higher (OR: 1.26; 95% CI: 1.11 – 1.43; p < 0.0.001) had a 1.2 times greater chance of being underweight.

As compared to normal mothers, those with an underweight mother (OR: 1.53; 95% CI: 1.41 – 1.65; p < 0.0.001) had 1.5 times higher odds of having underweight children. In comparison to normal mothers, those who were overweight mothers (OR: 0.65; 95% CI: 0.57 – 0.73; p < 0.0.001) had 35% lower odds of having underweight children. As compared to normal mothers, obese mothers (OR: 0.55; 95% CI: 0.44 – 0.68; p < 0.0.001) had 45% lesser odds of having underweight children.

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Table 4.6.7 shows the sensitivity and specificity of the model at 62.2 % and 62.3%, respectively. Sensitivity and specificity, however, may change based on the demands of the research and the need for diagnostic research. Area under the ROC Curve is 0.667 (95% CI: 0.659 – 0.676) (Figure 4.6.4).

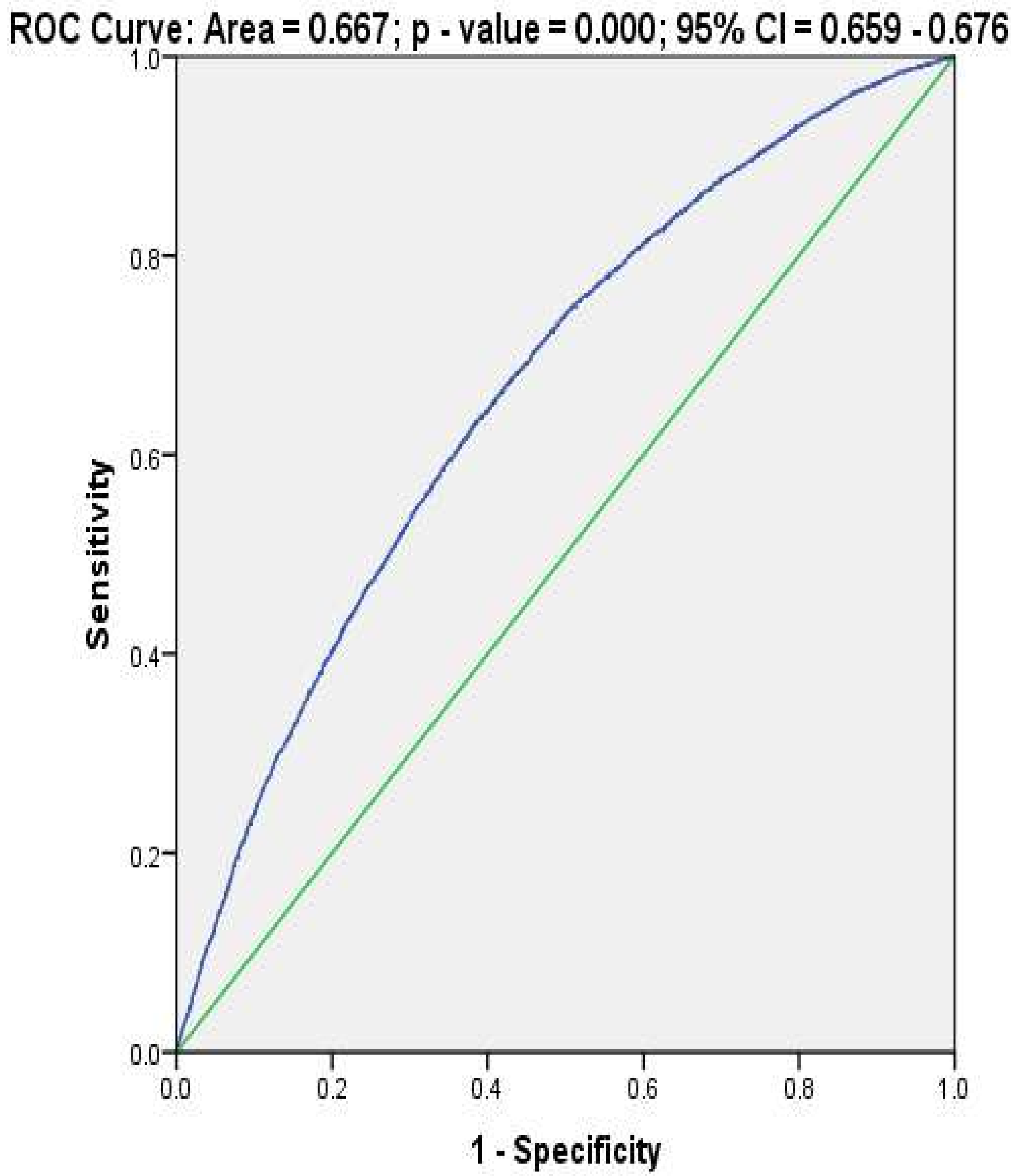


Figure. 4.6.4: - Receiving Operating Characteristic (ROC) Curve highlighting the results for Underweight in the Western Region of India

Table 4.6.7: - Sensitivity & Specificity of the model at different cut of points

Probability (≥)	**Probability**	**Specificity**
0.1901194	0.970	0.108
0.1902197	0.969	0.110
0.2067384	0.960	0.137
0.2069738	0.959	0.139
0.2173763	0.950	0.159
0.2174900	0.949	0.160
0.2257402	0.940	0.179
0.2257530	0.939	0.180
0.2348062	0.930	0.203
0.2348772	0.929	0.203
0.2414672	0.919	0.217
0.2469729	0.909	0.238
0.2668357	0.879	0.294
0.2770285	0.869	0.312
0.2835017	0.858	0.329
0.2957104	0.840	0.358
0.2957170	0.837	0.361
0.3010668	0.829	0.372
0.3465896	0.740	0.501
0.3466872	0.739	0.501
0.3501712	0.727	0.514
0.3681777	0.679	0.566
0.3728795	0.669	0.577
0.3777095	0.659	0.586
0.3811349	0.648	0.596
0.3867595	0.639	0.608
0.3914037	0.628	0.619
0.3943767	**0.622**	**0.623**
0.4335740	0.524	0.709
0.4399760	0.504	0.723
0.4864749	0.391	0.809
0.4973886	0.362	0.829
0.5451554	0.230	0.906
0.5613420	0.186	0.927

4.6.5 Estimation of Child Height

Table 4.6.8 represents the test between subjects' effects, reveals child age, birth order, type of residence, wealth index, BMI, child sex is having a significant effect on Child Height except education level and respondent occupation.

Table 4.6.8: Tests of Between-Subjects Effects

Dependent Variable: Child Height						
Source		Sum of Squares	d.f.	Mean Square	F	Sig.
Intercept	Hypothesis	569.351	1	569.351	13.103	< 0.001
	Error	95470.532	2197.102	43.453a		
Child Age	Hypothesis	838.174	4	209.543	4.882	< 0.001
	Error	152189.01	3546	42.919b		
Birth Order	Hypothesis	501.197	3	167.066	3.893	0.009
	Error	152189.01	3546	42.919b		
Education Level	Hypothesis	279.766	3	93.255	2.173	0.089
	Error	152189.01	3546	42.919b		
Respondent Occupation	Hypothesis	53.804	2	26.902	0.627	0.534
	Error	152189.01	3546	42.919b		
Type of residence	Hypothesis	218.036	1	218.036	5.08	0.024
	Error	152189.01	3546	42.919b		
Wealth Index	Hypothesis	1346.706	4	336.676	7.845	< 0.001
	Error	152189.01	3546	42.919b		
BMI	Hypothesis	655.856	3	218.619	5.094	0.002
	Error	152189.01	3546	42.919b		
Child Sex	Hypothesis	505.041	1	505.041	11.767	< 0.001
	Error	152189.01	3546	42.919b		
FIT*	Hypothesis	36363.242	1	36363.242	847.263	< 0.001
	Error	152189.01	3546	42.919b		
Birth Weight	Hypothesis	1237.842	1	1237.842	28.842	< 0.001
	Error	152189.01	3546	42.919b		
a .001 MS (Child Sex) + .999 MS (Error)						
b MS(Error)						

Note: - *Fit for Child height with Child age from CURVEFIT using Cubic Model –
$Child\ Height = 55.005 + 1.69\ Child\ age - 0.028\ Child\ age^2 + 0.000218\ Child\ age^3$

Table 4.6.9 represents factors associated with child height in western region. Children born in the first birth order (OR: 4.15, 95% CI: 1.81 – 9.55, $p < 0.05$) have a height which is around 4 times higher than children born in the 4 & above birth order. Children born in the second birth order (OR: 2.76, 95% CI: 1.20 – 6.33, $p < 0.05$) have a height which is 2.7 times higher than children born in the 4 & above birth order. Children born in the third birth order (OR: 2.63, 95% CI: 1.05 – 6.55, $p < 0.05$) have a height which is 2.6 times higher than children born in the 4 & above birth order.

Children's height is 74% less in mothers with no education (OR: 0.26, 95% CI: 0.09 – 0.73, $p < 0.05$) compared to mothers with higher education. Children's height is 62% less in mothers with primary education (OR: 0.38, 95% CI: 0.14 – 1.06, $p = 0.065$) compared to mothers with higher education. Children's height is 57% less in mothers with secondary education (OR: 0.43, 95% CI: 0.19 – 0.98, $p < 0.05$) compared to mothers with higher education.

Children's height is 28% less in mothers with no occupation (OR: 0.72, 95% CI: 0.40 – 1.32, $p = 0.293$) compared to agricultural mothers. As compared to agricultural mothers, the height of children is 10% less in mothers with other occupations (OR: 0.90, 95% CI: 0.33 – 2.46, $p = 0.841$). As compared to rural region, the height of children is 1.8 times high in urban region (OR: 1.84, 95% CI: 1.08 – 3.14, $p < 0.05$).

Children in the poorest group (OR: 0.07, 95% CI: 0.03 – 0.18, $p < 0.05$) have 93% less height than children in the richest group. Children in the poorer group (OR: 0.15, 95% CI: 0.06 – 0.34, $p < 0.05$) have 85% less height than children in the richest group. Children in the middle group (OR: 0.22, 95% CI: 0.10 – 0.48, $p < 0.05$) have 78% less height than children in the richest group. Children in the richer group (OR:

0.35, 95% CI: 0.17 – 0.71, $p < 0.05$) have 65% less height than children in the richest group.

The height of children with normal BMI (OR: 0.70, 95% CI: 0.21 – 2.36, $p = 0.561$) is 30% less than that of those with obese BMI. The height of children with underweight BMI (OR: 0.31, 95% CI: 0.09 – 1.12, $p = 0.073$) is 69% lesser than that of children with obese BMI. The height of children with overweight BMI (OR: 1.22, 95% CI: 0.33 – 4.52, $p = 0.765$) is 1.2 times more than that of children with obese BMI. As compared to female children, height of male children (OR: 2.13, 95% CI: 1.38 – 3.28, $p < 0.05$) is 2.1 times higher.

Table 4.6.9: Factors Associated with Child Height in Western Region

Dependent Variable: Child Height					
Parameter	B	p-value	95% CI		OR (95%CI)
			LL	UL	
Birth Order					
1	1.424	0.001	0.592	2.257	4.15 (1.81, 9.55)
2	1.016	0.016	0.186	1.845	2.76 (1.20, 6.33)
3	0.966	0.039	0.051	1.880	2.63 (1.05, 6.55)
4 & above	0				
Education Level					
No Education	-1.333	0.011	-2.357	-0.309	0.26 (0.09, 0.73)
Primary	-0.96	0.065	-1.979	0.059	0.38 (0.14, 1.06)
Secondary	-0.84	0.045	-1.661	-0.018	0.43 (0.19, 0.98)
Higher	0				
Respondent Occupation					
No Occupation	-0.322	0.293	-0.923	0.279	0.72 (0.40, 1.32)
Other	-0.103	0.841	-1.106	0.900	0.90 (0.33, 2.46)
Agriculture	0				
Type of Residence					
Urban	0.612	0.024	0.08	1.144	1.84 (1.08, 3.14)
Rural	0				
Wealth Index					
Poorest	-2.707	0.000	-3.686	-1.728	0.07 (0.03, 0.18)
Poorer	-1.924	0.000	-2.759	-1.089	0.15 (0.06, 0.34)
Middle	-1.5	0.000	-2.266	-0.735	0.22 (0.10, 0.48)
Richer	-1.05	0.003	-1.753	-0.347	0.35 (0.17, 0.71)
Richest	0				
BMI					
Normal	-0.362	0.561	-1.583	0.860	0.70 (0.21, 2.36)
Underweight	-1.169	0.073	-2.446	0.109	0.31 (0.09, 1.12)
Overweight	0.2	0.765	-1.11	1.509	1.22 (0.33, 4.52)
Obese	0				
Child Sex					
Male	0.756	0.001	0.324	1.188	2.13 (1.38, 3.28)
Female	0				
FIT*	1.107	0	1.032	1.181	3.03 (2.81, 3.26)
Birth Weight	1.582	0	1.004	2.160	4.86 (2.73, 8.67)

Note: - ***Fit for Child height with Child age from CURVEFIT using Cubic Model –

$$Child\ Height = 55.005 + 1.69\ Child\ age - 0.028\ Child\ age^2 + 0.000218\ Child\ age^3$$

Table 4.6.10 represents the descriptive statistics of child height by birth order. The mean height of a child in first and second birth order is around 84.5 cm and 84.1 cm, respectively. The mean height of a child in third and 4 & above birth order is around 84 cm and 83.1 cm, respectively.

Table 4.6.10: - Descriptive Statistics of child Height by Birth Order

Dependent Variable: Child Height				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	84.491	0.283	83.937	85.046
2	84.082	0.28	83.528	84.64
3	84.032	0.351	83.345	84.72
4 & above	83.067	0.42	82.251	83.88

Table 4.6.11 represents a pairwise comparison of child height by birth order. Mean difference of child height between first and second birth order (M D = 0.409, 95% CI: -0.09 to 0.91, p = 0.109), between first and third birth order (M D = 0.459, 95% CI: -0.22 to 1.13, p = 0.182) is statistically insignificant. But a mean difference of child height between first and 4 & above birth order (M D = 1.424, 95% CI: 0.59 to 2.26, $p < 0.05$) is statistically significant. Mean difference in child height between second and third birth order (M D = 0.05, 95% CI: -0.63 to 0.73, p = 0.885) is statistically insignificant. But, mean difference of child height between second and 4 & above birth order (M D = 1.016, 95% CI: 0.19 to 1.85, $p < 0.05$) is statistically significant. Mean difference of child height between third and 4 & above birth order (M D = 0.966, 95% CI: 0.05 to 1.88, $p < 0.05$).

Table 4.6.11: - Pairwise Comparison of Child Height by Birth Order

Dependent Variable: Child Height						
Birth Order	Birth Order	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
1	2	0.409	0.26	0.109	-0.09	0.91
	3	0.459	0.34	0.182	-0.22	1.13
	4 & above	1.424*	0.43	0.001	0.59	2.26
2	3	0.05	0.35	0.885	-0.63	0.73
	4 & above	1.016*	0.42	0.016	0.19	1.85
3	4 & above	.966*	0.47	0.039	0.05	1.88
*Mean difference is significant at the 0.05 level.						

Table 4.6.12 represents the descriptive statistics of child height by educational level. The mean height of a child for mothers with no education is around 83.3 cm. For mothers with primary education, the average height of the child is around 83.7 cm. For mothers with secondary education, the average height of the child is around 83.8 cm. Similarly, for mothers with higher education, the average child's height is around 84.7 cm.

Table 4.6.12: - Descriptive Statistics of Child Height by Educational Level

Dependent Variable: Child Height				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No Education	83.37	0.34	82.70	84.03
Primary	83.74	0.36	83.04	84.44
Secondary	83.86	0.27	83.34	84.39
Higher	84.70	0.45	83.83	85.57

Table 4.6.13 represents a pairwise comparison of child height by educational level. Mean difference in child height between mothers with no education and primary education (M D = -0.374, 95% CI: -1.15 to 0.40, $p = 0.345$) and mean difference in child height between mothers with no education and secondary education (M D = -0.493, 95% CI: -1.15 to 0.16, $p = 0.139$) is statistically insignificant. Mean difference of child height between mothers with no education and higher education (M D = -1.333, 95% CI: -2.36 to -0.31, $p < 0.05$) is statistically

significant. Mean difference of child height between mothers with primary and secondary education (M D = -0.12, 95% CI: -0.79 to 0.55, p = 0.724) is statistically insignificant. Also, mean difference of child height between mothers with primary and higher education (M D = -0.96, 95% CI: -1.98 to 0.06, p = 0.065) is statistically insignificant. Mean difference in child weight between mothers with secondary and higher education (M D = -0.840, 95% CI: -1.66 to -0.02, p < 0.05) is statistically significant.

Table 4.6.13: - Pairwise Comparison of Child Height by Educational Level

Dependent Variable: Child Height						
Educational Level	Educational Level	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
No education	Primary	-0.374	0.40	0.345	-1.15	0.40
	Secondary	-0.493	0.33	0.139	-1.15	0.16
	Higher	-1.333*	0.52	0.011	-2.36	-0.31
Primary	Secondary	-0.120	0.34	0.724	-0.79	0.55
	Higher	-0.960	0.52	0.065	-1.98	0.06
Secondary	Higher	-0.840*	0.42	0.045	-1.66	-0.02
*Mean difference is significant at the .05 level.						

Table 4.6.14 represents the descriptive statistics of child height by respondent occupation. Mean height of the child for mothers with no occupation is around 83.7 cm. But, for mothers with other occupation and agricultural mothers, average height of the child is around 83.9 cm and 84 cm, respectively.

Table 4.6.14: - Descriptive Statistics of Child Height by of Respondent Occupation

Dependent Variable: Child height				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	83.74	0.22	83.30	84.18
Other	83.96	0.45	83.07	84.85
Agriculture	84.06	0.33	83.42	84.70

Table 4.6.15 represents a pairwise comparison of child height by respondent occupation. Mean difference in child height between mothers with no occupation and mothers with other occupation (M D = -0.22, 95% CI: -1.09 to 0.65, p = 0.62) and mean difference in child height between mothers with no occupation and mothers doing agriculture (M D = -0.32, 95% CI: -0.92 to 0.28, p = 0.29) is statistically insignificant. Mean difference in child height between mothers with other occupation and mothers doing agriculture (M D = -0.10, 95% CI: -.11 to 0.90, p = 0.84) is statistically insignificant.

Table 4.6.15: - Pairwise Comparisons of Child Height by Respondent Occupation

Dependent Variable: Child Height						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
No Occupation	Other	-0.22	0.443	0.62	-1.09	0.65
	Agriculture	-0.32	0.307	0.29	-0.92	0.28
Other	Agriculture	-0.10	0.511	0.84	-1.11	0.90

Table 4.6.16 represents the descriptive statistics of Child Height by Type of Residence. Mean height of children in urban as well as rural regions is around 84.2 cm and 83.6 cm, respectively.

Table 4.6.16: - Descriptive Statistics of Child Height by Type of Residence

Dependent Variable: Child Height				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	84.224	0.291	83.654	84.794
Rural	83.612	0.265	83.093	84.132

Table 4.6.17 represents a pairwise comparison of child height by Type of Residence. Mean difference in child height between urban region and rural region (M D = 0.612, 95% CI: 0.08 to 1.14, $p < 0.05$), is statistically insignificant.

Table 4.6.17: - Pairwise Comparison of Child Height of Type of Place of Residence

Dependent Variable: Child Height						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Urban	Rural	0.612*	0.27	0.024	0.08	1.14
*Mean difference is significant at the 0.05 level.						

Table 4.6.18 represents the descriptive statistics of child height by wealth index. The average height of a child in the poorest group is around 82.6 cm. In the poorer and middle groups, children's average height is around 83.4 cm and 83.8 cm, respectively. Similarly, in richer as well as richest groups, the average height of children is around 84.3 cm and 85.3 cm, respectively.

Table 4.6.18: - Descriptive Statistics of Child Height of Wealth Index

Dependent Variable: Child Height				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	82.65	0.40	81.86	83.44
Poorer	83.43	0.35	82.75	84.11
Middle	83.85	0.33	83.21	84.49
Richer	84.31	0.33	83.66	84.95
Richest	85.36	0.34	84.69	86.02

Table 4.6.19 represents a pairwise comparison of child height by Wealth Index. Mean difference of child height between poorest group and poorer group (M D = - 0.783, 95% CI: -1.56 to -0.01, $p < 0.05$), between poorest group and middle group (M D = - 1.207, 95% CI: -2.00 to -0.42, $p < 0.05$), between poorest group and richer group (M D = -1.657, 95% CI: -2.52 to -0.80, $p < 0.05$), and between poorest group and richest group (M D = -2.707, 95% CI: -3.69 to –1.73, $p < 0.05$) is statistically

significant. Mean difference in child height between poorer group and middle group (M D = - 0.424, 95% CI: -1.09 to 0.24, $p = 0.211$) is statistically insignificant. Mean difference in child height between poorer group and richer group (M D = -0.874, 95% CI: -1.59 to – 0.16, $p < 0.05$), and between poorer group and richest group (M D = - 1.924, 95% CI: -2.76 to –1.09, $p < 0.05$) is statistically significant. Mean difference in child height between middle group and richer group (M D = -0.45, 95% CI: -1.11q to 0.21, $p = 0.180$) is statistically insignificant. Mean difference in child height between middle group and the richest group (M D = -1.500, 95% CI: -2.27 to – 0.74, $p < 0.05$) is statistically significant. Mean difference in child height between richer and the richest group (M D = -1.050, 95% CI: -1.75 to – 0.35, $p < 0.05$) is statistically significant.

Table 4.6.19: - Pairwise Comparisons of Child Height by Wealth Index

Dependent Variable: Child Height						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Poorest	Poorer	-0.783*	0.40	0.048	-1.56	-0.01
	Middle	-1.207*	0.40	0.003	-2.00	-0.42
	Richer	-1.657*	0.44	0.000	-2.52	-0.80
	Richest	-2.707*	0.50	0.000	-3.69	-1.73
Poorer	Middle	-0.424	0.34	0.211	-1.09	0.24
	Richer	-0.874*	0.37	0.017	-1.59	-0.16
	Richest	-1.924*	0.43	0.000	-2.76	-1.09
Middle	Richer	-0.450	0.34	0.180	-1.11	0.21
	Richest	-1.500*	0.39	0.000	-2.27	-0.74
Richer	Richest	-1.050*	0.36	0.003	-1.75	-0.35
* Mean difference is significant at the 0.05 level.						

Table 4.6.20 represents the descriptive statistics of Child Height by Child Sex. The average height of a child in males is around 84.3 cm. Similarly, children's average height in females is around 83.5 cm.

Table 4.6.20: - Descriptive Statistics of Child Height by Child Sex

Dependent Variable: Child Height				
Child Sex	Mean	Std. Error	95% CI	
			LL	UL
Male	84.30	0.27	83.78	84.82
Female	83.54	0.27	83.02	84.07

Table 4.6.21 represents a pairwise comparison of child height by Child Sex. Mean difference of child height between male children and female children (M D = 0.756, 95% CI: 0.32 to 1.19, $p < 0.05$) is statistically significant.

Table 4.6.21: - Pairwise Comparison of Child Height by Child Sex

Dependent Variable: Child Height						
Child Sex	Child Sex	Mean Difference	Std. Error	p-value	95% CI for Difference	
					LL	UL
Male	Female	0.756*	0.22	0.001	0.32	1.19
*Mean difference is significant at the 0.05 level.						

Table 4.6.22 represents the descriptive statistics of Child Height by BMI. The average height of a child with a normal BMI as well as an underweight BMI is around 83.8 cm and 83 cm. The average height of a child with an overweight BMI is around 84.4 cm. Similarly, children's average height in obese BMI is around 84.2 cm.

Table 4.6.22: - Descriptive Statistics of Child Height by BMI

Dependent Variable: Child Height				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	83.889	0.221	83.455	84.323
Underweight	83.082	0.269	82.555	83.61
Overweight	84.450	0.353	83.759	85.142
Obese	84.251	0.623	83.028	85.473

Table 4.6.23 represents a pairwise comparison of child height by BMI. Mean difference of child height between normal BMI and underweight BMI (M D = 0.807, 95% CI: 0.296 to 1.317, $p < 0.05$) is statistically significant. Mean difference of child height between normal BMI and overweight BMI (M D = - 0.561, 95% CI: -1.236 to 0.113, $p = 0.103$), and between normal BMI and obese BMI (M D = -0.362, 95% CI: -1.583 to 0.860, $p = 0.561$) is statistically insignificant. Mean difference of child height between underweight BMI and overweight BMI (M D = -1.368, 95% CI: -2.127 to –0.609, $p < 0.05$) is statistically significant. But, mean difference of child height between underweight BMI and obese BMI (M D = -1.169 95% CI: -2.446 to 0.109, $p = 0.073$) is statistically insignificant. Mean difference of child height between overweight BMI and obese BMI (M D = 0.200 95% CI: -1.110 to 1.509, $p = 0.765$) is statistically insignificant.

Table 4.6.23: - Pairwise Comparison of Child Height by BMI

Dependent Variable: Child height						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI for Difference	
					LL	UL
Normal	Underweight	0.807*	0.26	0.002	0.296	1.317
	Overweight	-0.561	0.344	0.103	-1.236	0.113
	Obese	-0.362	0.623	0.561	-1.583	0.860
Underweight	Overweight	-1.368*	0.387	0.000	-2.127	-0.609
	Obese	-1.169	0.651	0.073	-2.446	0.109
Overweight	Obese	0.200	0.668	0.765	-1.110	1.509
*Mean difference is significant at the 0.05 level.						

4.6.6 Estimation of Child Weight

Table 4.6.24 represents the test between subjects' effects, reveals child age, wealth index, sex of child and BMI is having a significant effect on Child Weight except respondent occupation, birth order, educational level & type of residence.

Table 4.6.24: Tests of Between-Subjects Effects

Dependent Variable: Child Weight						
Source		Sum of Squares	d.f.	Mean Square	F	p - value
Intercept	Hypothesis	14.857	1	14.857	4.351	0.044
	Error	128.855	37.733	3.415a		
Child Age	Hypothesis	179.931	4	44.983	15.662	< 0.001
	Error	10135.609	3529	2.872b		
Birth Order	Hypothesis	17.442	3	5.814	2.024	0.108
	Error	10135.609	3529	2.872b		
Educational Level	Hypothesis	17.24	3	5.747	2.001	0.112
	Error	10135.609	3529	2.872b		
Respondent Occupation	Hypothesis	2.057	2	1.029	0.358	0.699
	Error	10135.609	3529	2.872b		
Type of Residence	Hypothesis	0.202	1	0.202	0.07	0.791
	Error	10135.609	3529	2.872b		
Wealth Index	Hypothesis	139.299	4	34.825	12.125	< 0.001
	Error	10135.609	3529	2.872b		
BMI	Hypothesis	167.766	3	55.922	19.471	< 0.001
	Error	10135.609	3529	2.872b		
Child Sex	Hypothesis	144.524	1	144.524	50.32	< 0.001
	Error	10135.609	3529	2.872b		
FIT*	Hypothesis	1711.034	1	1711.034	595.745	< 0.001
	Error	10135.609	3529	2.872b		
Birth Weight	Hypothesis	116.034	1	116.034	40.4	< 0.001
	Error	10135.609	3529	2.872b		
a .004 MS (Child Sex) + .996 MS (Error)						
b MS(Error)						

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.218\ Child\ Age^{0.353}$$

Table 4.6.25 represents factors associated with child weight in western region. Children under the age of 12 months (OR: 1.07, 95% CI: 0.58 – 1.96, $p = 0.834$) weigh more when compared with children who are between aged group 48 and 59 months. The weight of children between the ages of 12 and 23 months (OR: 0.70, 95% CI: 0.47 – 1.04, $p = 0.074$) is 30 % lesser than that of children between the ages of 48 and 59 months. Children between the ages of 24 and 35 months (OR: 0.57, 95% CI: 0.44 – 0.76, $p < 0.05$) weigh 43% lesser than children between the ages of 48 and 59 months. When compared to children between the ages of 48 and 59 months, children between the ages of 36 and 47 months (OR: 0.72, 95% CI: 0.59 – 0.88, $p < 0.05$) weigh 28% less.

Children born in the first birth order (OR: 1.31, 95% CI: 1.06 – 1.62, $p < 0.05$) weigh 1.3 times more than children born in the 4 & above birth order. Children born in the second birth order (OR: 1.23, 95% CI: 0.99 – 1.53, $p = 0.057$) weigh 1.2 times more than children born in the 4 & above birth order. Children born in the third birth order (OR: 1.24, 95% CI: 0.98 – 1.57, $p = 0.076$) weigh 1.2 times more than children born in the 4 & above birth order.

Children's weight is 26% less in mothers with no education (OR: 0.74, 95% CI: 0.56 – 0.96, $p < 0.05$) compared to mothers with higher education. Children's weight is 12% less in mothers with primary education (OR: 0.88, 95% CI: 0.68 – 1.14, $p = 0.338$) compared to mothers with higher education. Children's weight is 15% less in mothers with secondary education (OR: 0.85, 95% CI: 0.68 – 1.05, $p = 0.122$) compared to mothers with higher education.

Children's weight is 6% less in mothers with no occupation (OR: 0.94, 95% CI: 0.81 – 1.10, $p = 0.464$) compared to agricultural mothers. As compared to agricultural mothers, the weight of children is more in mothers with other occupations

(OR: 1.00, 95% CI: 0.77 – 1.30, p = 0.996). As compared to rural region, the weight of children is more in urban region (OR: 1.02, 95% CI: 0.89 – 1.17, p = 0.791).

Children in the poorest group (OR: 0.46, 95% CI: 0.36 – 0.60, $p < 0.05$) have 54% less weight than children in the richest group. Children in the poorer group (OR: 0.52, 95% CI: 0.42 – 0.65, $p < 0.05$) have 48% less weight than children in the richest group. Children in the middle group (OR: 0.59, 95% CI: 0.48 – 0.71, $p < 0.05$) have 41% less weight than children in the richest group. Children in the richer group (OR: 0.79, 95% CI: 0.66 – 0.94, $p < 0.05$) have 21% less weight than children in the richest group.

The weight of children with normal woman (OR: 0.53, 95% CI: 0.38 – 0.72, $p < 0.05$) is 47% lesser than that of those with obese woman. The weight of children with underweight woman (OR: 0.39, 95% CI: 0.28 – 0.54, $p < 0.05$) is around 61% lesser than that of children with obese woman. The weight of children with overweight woman (OR: 0.73, 95% CI: 0.52 – 1.03, p = 0.072) is 27% lesser than that of children with obese woman. As compared to female children, weight of male children (OR: 1.50, 95% CI: 1.34 – 1.68, $p < 0.05$) is around 2 times higher.

Table 4.6.25: Factors Associated with Child Weight in Western Region

Dependent Variable: Child Weight					
			95% CI		
Parameter	B	p – value	LL	UL	OR (95% CI)
Child Age (Months)					
< 12	0.065	0.834	-0.541	0.671	1.07 (0.58, 1.96)
12 - 23	-0.359	0.074	-0.753	0.035	0.70 (0.47, 1.04)
24 - 35	-0.555	0.000	-0.829	-0.281	0.57 (0.44, 0.76)
36 - 47	-0.327	0.001	-0.525	-0.13	0.72 (0.59, 0.88)
48 – 59 *(Ref.)*	0				
Birth Order					
1	0.27	0.014	0.054	0.485	1.31 (1.06, 1.62)
2	0.209	0.057	-0.006	0.424	1.23 (0.99, 1.53)
3	0.215	0.076	-0.022	0.452	1.24 (0.98, 1.57)
4 & above *(Ref.)*	0				
Education Level					
No Education	-0.306	0.024	-0.572	-0.041	0.74 (0.56, 0.96)
Primary	-0.129	0.338	-0.393	0.135	0.88 (0.68, 1.14)
Secondary	-0.168	0.122	-0.381	0.045	0.85 (0.68, 1.05)
Higher *(Ref.)*	0				
Respondent Occupation					
No Occupation	-0.058	0.464	-0.214	0.098	0.94 (0.81, 1.10)
Others	-0.001	0.996	-0.26	0.259	1.00 (0.77, 1.30)
Agriculture *(Ref.)*	0				
Type of Residence					
Urban	0.019	0.791	-0.119	0.157	1.02 (0.89, 1.17)
Rural *(Ref.)*	0				
Wealth Index					
Poorest	-0.773	0.000	-1.027	-0.518	0.46 (0.36, 0.60)
Poorer	-0.655	0.000	-0.871	-0.438	0.52 (0.42, 0.65)
Middle	-0.535	0.000	-0.734	-0.337	0.59 (0.48, 0.71)
Richer	-0.239	0.010	-0.421	-0.057	0.79 (0.66, 0.94)
Richest *(Ref.)*	0				
BMI					
Normal	-0.643	0.000	-0.958	-0.328	0.53 (0.38, 0.72)
Underweight	-0.949	0.000	-1.278	-0.619	0.39 (0.28, 0.54)
Overweight	-0.309	0.072	-0.647	0.028	0.73 (0.52, 1.03)
Obese *(Ref.)*	0				
Child Sex					
Male	0.405	0.000	0.293	0.517	1.50 (1.34, 1.68)
Female *(Ref.)*	0				
FIT*	1.049	0.000	0.965	1.133	2.85 (2.62, 3.10)
Birth Weight	0.486	0.000	0.336	0.636	1.63 (1.40, 1.89)

Note: *Fit for Child Weight with child age from CURVEFIT using Power Model:

$$Child\ Weight = 3.218\ Child\ Age^{0.353}$$

Table 4.6.26 represents the descriptive statistics of child weight by child age. The mean weight of a child in less than 12 months age group is around 10.8 kg. The mean weight of a child in 12 - 23 months and 24 - 35 months age group is around 10.4 kg and 10.2 kg, respectively. The mean weight of a child in 36 - 47 months age group is around 10.4 kg. The mean weight of a child in 48 - 59 months age group is around 10.7 kg.

Table 4.6.26: Descriptive Statistics of Child Weight by Child Age

Dependent Variable: Child Weight				
Child Age	Mean	Std. Error	95% CI	
			LL	UL
<12	10.825	0.190	10.452	11.198
12 - 23	10.401	0.103	10.199	10.603
24 - 35	10.205	0.089	10.031	10.379
36 - 47	10.432	0.114	10.210	10.655
48 - 59	10.760	0.150	10.465	11.055

Table 4.6.27 represents a pairwise comparison of child weight by child age. Mean difference of child weight between less than 12 months and 12 – 23 months age group (M D = 0.424, 95% CI: 0.132 to 0.716, $p < 0.05$) is statistically significant. Mean difference of child weight between < 12 months and 24 - 35 months age group (M D = 0.620, 95% CI: 0.207 to 1.032, $p < 0.05$) is statistically significant. Mean difference of child weight between 24 - 35 months and 36 - 47 months age group (M D = - 0.228, 95% CI: -0.438 to - 0.018, $p < 0.05$), between 24 - 35 months and 48 - 59 months age group (M D = - 0.555, 95% CI: -0.829 to - 0.281, $p < 0.05$) is statistically significant. Mean difference of child weight between 36 - 47 months and 48 - 59 months age group (M D = -0.327, 95% CI: -0.525 to - 0.13, $p < 0.05$) is statistically significant.

Table 4.6.27: Pairwise Comparisons of Child Weight by Child Age

Dependent Variable: Child Weight						
Child Age	Child Age	Mean Difference	Std. Error	p -value	95% CI	
					LL	UL
<12	12 - 23	0.424*	0.149	0.004	0.132	0.716
	24 - 35	0.620*	0.21	0.003	0.207	1.032
	36 - 47	0.392	0.263	0.136	-0.124	0.908
	48 - 59	0.065	0.309	0.834	-0.541	0.671
12 - 23	24 - 35	0.196	0.119	0.099	-0.037	0.428
	36 - 47	- 0.032	0.159	0.843	-0.344	0.281
	48 - 59	-0.359	0.201	0.074	-0.753	0.035
24 - 35	36 - 47	-0.228*	0.107	0.034	-0.438	-0.018
	48 - 59	-0.555*	0.14	0.000	-0.829	-0.281
36 - 47	48 - 59	-0.327*	0.101	0.001	-0.525	-0.13
*Mean difference is significant at the 0.05 level.						

Table 4.6.28 represents the descriptive statistics of child weight by birth order. The mean weight of a child in the first birth order is around 10.6 kg. The mean weight of a child in the second birth order is around 10.5 kg. For third birth order, mean weight of a child is around 10.6 kg. Similarly, for 4 & above birth order, mean weight of a child is around 10.3 kg.

Table 4.6.28: Descriptive Statistics of Child Weight by Birth Order

Dependent Variable: Child Weight				
Birth Order	Mean	Std. Error	95% CI	
			LL	UL
1	10.621	0.073	10.477	10.764
2	10.560	0.073	10.417	10.704
3	10.566	0.091	10.388	10.745
4 & above	10.351	0.107	10.141	10.562

Table 4.6.29 represents a pairwise comparison of child weight by birth order. Mean difference of child weight between first and second birth order (M D = 0.061, 95% CI: -0.069 to 0.19, $p = 0.358$), between first and third birth order (M D = 0.055, 95% CI: -0.121 to 0.23, $p = 0.540$) is statistically insignificant. But, mean difference of child weight between first and 4 & above birth order (M D = 0.270, 95% CI: 0.054 to 0.485, $p < 0.05$) is statistically significant. The mean weight difference in children

between second and third birth orders (M D = -0.006, 95% CI: -0.182 to 0.17, p = 0.947) as well as between second and 4 & above birth orders (M D = 0.209, 95% CI: -0.006 to 0.424, p = 0.057) is statistically insignificant. The mean weight difference in children between third and 4 & above birth orders (M D = 0.215, 95% CI: -0.022 to 0.452, p = 0.076) is statistically insignificant.

Table 4.6.29: Pairwise Comparisons of Child Weight by Birth Order

Dependent Variable: Child Weight						
Birth Order	Birth Order	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
1	2	0.061	0.066	0.358	-0.069	0.19
	3	0.055	0.089	0.540	-0.121	0.23
	4 & above	0.270*	0.11	0.014	0.054	0.485
2	3	-0.006	0.09	0.947	-0.182	0.17
	4 & above	0.209	0.11	0.057	-0.006	0.424
3	4 & above	0.215	0.121	0.076	-0.022	0.452
*Mean difference is significant at the .05 level.						

Table 4.6.30 represents the descriptive statistics of child weight by educational level. The mean weight of a child for mothers with no education is around 10.3 kg. For mothers with primary education, average weight of the child is around 10.5 kg. For mothers with secondary education, average weight of the child is around 10.5 kg. Similarly, for mothers with higher education, the average child's weight is around 10.6 kg.

Table 4.6.30: Descriptive Statistics of Child Weight by Educational Level

Dependent Variable: Child Weight				
Educational Level	Mean	Std. Error	95% CI	
			LL	UL
No education	10.369	0.088	10.197	10.541
Primary	10.546	0.092	10.365	10.727
Secondary	10.508	0.069	10.372	10.643
Higher	10.675	0.115	10.449	10.901

Table 4.6.31 represents a pairwise comparison of child weight by educational level. Mean difference of child weight between mothers with no education and primary education (M D = -0.177, 95% CI: -0.379 to 0.024, p = 0.084) as well as Mean difference of child weight between mothers with no education and secondary education (M D = -0.139, 95% CI: - 0.308 to 0.031, p = 0.109) is statistically insignificant. But, mothers with no education and higher education (M D = -0.306, 95% CI: - 0.572 to -0.041, p < 0.05) is statistically significant. Mean difference of child weight between mothers with primary and secondary education (M D = 0.039, 95% CI: - 0.134 to 0.211, p = 0.660) is statistically insignificant. Mean difference of child weight between mothers with primary and higher education (M D = -0.129, 95% CI: - 0.393 to 0.135, p = 0.338) is statistically insignificant. Mean difference of child weight between mothers with secondary and higher education (M D = -0.168, 95% CI: - 0.381 to 0.045, p = 0.122) is statistically insignificant.

Table 4.6.31: Pairwise Comparison of Child Weight by Educational Level

Dependent Variable: Child Weight						
Educational Level	Educational Level	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No Education	Primary	-0.177	0.103	0.084	-0.379	0.024
	Secondary	-0.139	0.086	0.109	-0.308	0.031
	Higher	-.306*	0.135	0.024	-0.572	-0.041
Primary	Secondary	0.039	0.088	0.66	-0.134	0.211
	Higher	-0.129	0.135	0.338	-0.393	0.135
Secondary	Higher	-0.168	0.109	0.122	-0.381	0.045
*Mean difference is significant at the 0.05 level.						

Table 4.6.32 represents the descriptive statistics of child weight by respondent occupation. Mean weight of the child for mothers with no occupation is around 10.4 kg. For mothers with other occupation and agricultural mothers, average weight of the child is around 10.5 kg and 10.5 kg, respectively.

Table 4.6.32: Descriptive Statistics of Child Weight by Respondent Occupation

Dependent Variable: Child Weight				
Respondent Occupation	Mean	Std. Error	95% CI	
			LL	UL
No Occupation	10.486	0.058	10.373	10.599
Other	10.543	0.117	10.314	10.773
Agriculture	10.544	0.084	10.379	10.709

Table 4.6.33 represents a pairwise comparison of child weight by respondent occupation. Mean difference of child weight between mothers with no occupation and other occupation (M D = -0.057, 95% CI: -0.282 to 0.168, p = 0.617), between mothers with no occupation and agricultural mothers (M D = -0.058, 95% CI: -0.214 to 0.098, p = 0.464) is statistically insignificant. Similarly, mean difference of child weight between mothers' other occupation and agricultural mothers (M D = -0.001, 95% CI: -0.260 to 0.259, p = 0.996) is statistically insignificant.

Table 4.6.33: Pairwise Comparison of Child Weight by Respondent Occupation

Dependent Variable: Child Weight						
Respondent Occupation	Respondent Occupation	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
No Occupation	Other	-0.057	0.115	0.617	-0.282	0.168
	Agriculture	-0.058	0.079	0.464	-0.214	0.098
Other	Agriculture	-0.001	0.132	0.996	-0.260	0.259

Table 4.6.34 represents the descriptive statistics of child weight by type of residence. Mean weight of child in urban is around 10.5 kg and mean weight of child in rural is around 10.5 kg.

Table 4.6.34: Descriptive Statistics of Child Weight by Type of Residence

Dependent Variable: Child Weight				
Type of Residence	Mean	Std. Error	95% CI	
			LL	UL
Urban	10.534	0.075	10.386	10.681
Rural	10.515	0.068	10.381	10.649

Table 4.6.35 represents a pairwise comparison of child weight by type of residence. Mean difference of child weight between urban and rural region (M D = 0.019, 95% CI: -0.119 to 0.157, p = 0.791) is statistically insignificant.

Table 4.6.35: Pairwise Comparisons of Child Weight by Type of Residence

Dependent Variable: Child Weight						
Type of Residence	Type of Residence	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Urban	Rural	0.019	0.07	0.791	-0.119	0.157

Table 4.6.36 represents the descriptive statistics of child weight by wealth index. The average weight of a child in the poorest group is around 10.1 kg. In the poorer groups, children's average weight is around 10.3 kg. In the middle groups, children's average weight is around 10.4 kg. Similarly, in richer as well as richest groups, the average weight of children is around 10.7 kg and 10.9 kg, respectively.

Table 4.6.36: Descriptive Statistics of Child weight by Wealth Index

Dependent Variable: Child Weight				
Wealth Index	Mean	Std. Error	95% CI	
			LL	UL
Poorest	10.192	0.104	9.988	10.397
Poorer	10.310	0.090	10.134	10.487
Middle	10.429	0.084	10.264	10.595
Richer	10.726	0.085	10.560	10.892
Richest	10.965	0.088	10.792	11.138

Table 4.6.37 represents a pairwise comparison of child weight by wealth index. Mean difference of child weight between poorest group and middle group (M D = - 0.237, 95% CI: -0.443 to - 0.032, $p < 0.05$), between poorest group and richer group (M D = - 0.534, 95% CI: - 0.758 to - 0.310, $p < 0.05$), and between poorest group and richest group (M D = - 0.773, 95% CI: - 1.027 to - 0.518, $p < 0.05$) is statistically significant. Mean difference of child weight between poorer group and richer group (M D = - 0.416, 95% CI: - 0.602 to – 0.229, $p < 0.05$), between poorer group and richest group (M D = - 0.655, 95% CI: - 0.871 to – 0.438, $p < 0.05$) is statistically significantly. Mean difference of child weight between middle and richer group (M D = - 0.296, 95% CI: - 0.467 to – 0.126, $p < 0.05$) and between middle and richest group (M D = - 0.535, 95% CI: - 0.734 to – 0.337, $p < 0.05$) is statistically significant. Mean difference of child weight between richer and richest group (M D = - 0.239, 95% CI: -0.421 to – 0.057, $p < 0.05$) is statistically significant.

Table 4.6.37: Pairwise Comparisons of Child weight by Wealth Index

Dependent Variable: Child Weight						
Wealth Index	Wealth Index	Mean Difference	Std. Error	p -value	95% CI	
					LL	UL
Poorest	Poorer	-0.118	0.103	0.251	-0.32	0.084
	Middle	-0.237*	0.105	0.024	-0.443	-0.032
	Richer	-0.534*	0.114	0.000	-0.758	-0.31
	Richest	-0.773*	0.13	0.000	-1.027	-0.518
Poorer	Middle	-0.119	0.088	0.176	-0.291	0.053
	Richer	-0.416*	0.095	0.000	-0.602	-0.229
	Richest	-0.655*	0.11	0.000	-0.871	-0.438
Middle	Richer	-0.296*	0.087	0.001	-0.467	-0.126
	Richest	-0.535*	0.101	0.000	-0.734	-0.337
Richer	Richest	-0.239*	0.093	0.01	-0.421	-0.057
*Mean difference is significant at the .05 level.						

Table 4.6.38 represents the descriptive statistics of child weight by BMI. The average weight of a child with a normal woman is around 10.3 kg. The average weight of a child in underweight woman is around 10 kg. The average weight of a child in an overweight woman is around 10.6 kg. Similarly, children's average weight in obese woman is around 11 kg.

Table 4.6.38: Descriptive Statistics of Child Weight by BMI

Dependent Variable: Child Weight				
BMI	Mean	Std. Error	95% CI	
			LL	UL
Normal	10.357	0.057	10.244	10.469
Underweight	10.051	0.070	9.915	10.188
Overweight	10.690	0.091	10.512	10.869
Obese	11.000	0.161	10.685	11.315

Table 4.6.39 represents a pairwise comparison of child weight by BMI. Mean difference of child weight between normal woman and underweight woman (M D = 0.306, 95% CI: 0.173 to 0.438, $p < 0.05$), between normal woman and overweight woman (M D = - 0.333, 95% CI: - 0.508 to - 0.159, $p < 0.05$) is statistically significant. Also, mean difference of child weight between normal woman and obese woman (M D = - 0.643, 95% CI: - 0.958 to - 0.328, $p < 0.05$) is statistically significant. Mean difference of child weight between underweight woman and overweight woman (M D = - 0.639, 95% CI: -0.835 to -0.443, $p < 0.05$) and underweight woman and obese woman (M D = - 0.949, 95% CI: -0.647 to 0.028, $p < 0.05$) is statistically significant.

Table 4.6.39: Pairwise Comparison of Child Weight by BMI

Dependent Variable: Child Weight						
BMI	BMI	Mean Difference	Std. Error	p - value	95% CI	
					LL	UL
Normal	Underweight	0.306*	0.068	0.000	0.173	0.438
	Overweight	-0.333*	0.089	0.000	-0.508	-0.159
	Obese	-0.643*	0.161	0.000	-0.958	-0.328
Underweight	Overweight	-0.639*	0.100	0.000	-0.835	-0.443
	Obese	-0.949*	0.168	0.000	-1.278	-0.619
Overweight	Obese	-0.309	0.172	0.072	-0.647	0.028
*Mean difference is significant at the .05 level.						

Table 4.6.40 represents the descriptive statistics of child weight by child sex. The average weight of a child in males is around 10.7 kg. Similarly, children's average weight in females is around 10.3 kg.

Table 4.6.40: Descriptive Statistics of Child Weight by Child Sex

Dependent Variable: Child Weight				
Sex of child	Mean	Std. Error	95% CI	
			LL	UL
Male	10.727	0.069	10.593	10.862
Female	10.322	0.069	10.186	10.458

Table 4.6.41 represents a pairwise comparison of child weight by Child Sex. Mean difference of child weight between in male children and female children (M D = 0.405, 95% CI: 0.293 to 0.517, $p < 0.05$) is statistically significant.

Table 4.6.41: Pairwise Comparison of Child Weight by Child Sex

Dependent Variable: Child Weight						
Sex of child	Sex of child	Mean Difference	Std. Error	p -value	95% CI	
					LL	UL
Male	Female	.405*	0.057	0.000	0.293	0.517
*Mean difference is significant at the .05 level.						

4.6.7 Growth Nomogram

Table 4.6.42: Birth-weight categories of under-5 Children by their socio-demographic characteristics in West Region of India

		Birthweight (gm)								
		< 2000		2000 - 2499		2500 - 2999		3000+		Total
		n_1	%	n_2	%	n_3	%	n_4	%	n
Child Age (Months)	<12	220	3.5	1031	16.3	2156	34.1	2920	46.1	6327
	12 -23	224	4.2	717	13.3	1895	35.1	2556	47.4	5391
	24 - 35	231	3.8	894	14.6	2225	36.3	2782	45.4	6133
	36 - 47	272	4.3	856	13.4	2084	32.6	3181	49.8	6392
	48 - 59	258	4.2	684	11.2	1977	32.4	3189	52.2	6108
		Chi Square (d.f. = 12) = 130.267. p < 0.001								
Sex of Child	Boys	750	4.5	2056	12.3	5422	32.5	8439	50.6	16668
	Girls	641	4.2	2345	15.5	5264	34.8	6894	45.5	15143
		Chi Square (d.f. = 3) = 112.877. p < 0.001								
Birth Order	1	672	4.9	2055	15.1	4837	35.6	6013	44.3	13577
	2	386	3.5	1438	13	3791	34.3	5449	49.2	11064
	3	191	4.2	607	13.2	1307	28.4	2490	54.2	4595
	4 & above	142	5.5	300	11.7	752	29.2	1381	53.6	2575
		Chi Square (d.f. = 9) = 235.490. p < 0.001								
BMI (Kg/m2)	< 18.5	401	4.7	1514	17.6	3082	35.8	3609	41.9	8605
	18.5 -24.9	716	4.2	2257	13.2	5615	32.9	8485	49.7	17074
	25.0 - 29.9	181	4.3	387	9.2	1423	33.8	2214	52.7	4204
	≥ 30	67	6	116	10.4	339	30.6	586	52.9	1108
		Chi Square (d.f. = 9) = 295.533, p < 0.001								
Highest Educational Level	No education	189	4	684	14.5	1386	29.4	2452	52	4711
	Primary	165	4.1	570	14.2	1281	31.8	2008	49.9	4024
	Secondary	860	4.4	2772	14.3	6621	34.2	9104	47	19357
	Higher	177	4.8	375	10.1	1398	37.6	1770	47.6	3719
		Chi Square (d.f. = 9) = 117.226, p < 0.001								
Respondent Occupation	No Occupation	160	3.4	647	13.8	1581	33.7	2299	49.1	4687
	Others	15	3	52	10.2	162	31.6	282	55.2	511
	Agriculture	35	3.2	146	13.4	356	32.8	550	50.7	1087
	Don't Know	4	8.3	16	31.8	17	32.9	14	27	51
		Chi Square (d.f. = 9) = 29.320, p < 0.001								
Type of Residence	Urban	577	4.2	1813	13.2	4665	34.1	6643	48.5	13699
	Rural	814	4.5	2588	14.3	6021	33.2	8690	48	18113
		Chi Square (d.f. = 3) = 9.640, p = 0.022								
Wealth Index	Poorest	162	4.9	513	15.7	923	28.3	1667	51.1	3264
	Poorer	281	4.7	838	14	1994	33.3	2872	48	5985
	Middle	282	3.7	1138	15.1	2671	35.3	3467	45.9	7558
	Richer	361	4.4	1209	14.7	2710	32.9	3950	48	8230
	Richest	305	4.5	702	10.4	2389	35.3	3377	49.9	6774
		Chi Square (d.f. = 12) = 150.651, p < 0.001								

Birth-weight by Socio-demographic characteristics

Table 4.6.42 shows the distribution of under-5 children by their birth-weight categories and socio-demographic characteristics in the Western Region of India. Distribution of under-5 children by age and birth weight revealed that 3.5% to 4.3% of children had birth weights under 2000 gm, 11.2% to 16.3% had birth weights between 2000 gm and 2499 gm, 32.4% to 36.3% had birth weights between 2500 gm and 2999 gm, and 45.4% to 52.2% had birth weights of 3000 g or more. The age of children and their birth weight were shown to be significantly correlated $\left(\chi^2_{df=12} = 130.267, p < 0.001\right)$. More number of boys (50.6%) had their birth-weight 3000 gm & more than girls (45.5%). Also, for the birth weight less than 2000 gm, there were more boys (4.5%) than girls (4.2%). Similarly, there was more number of girls for the birth-weight group 2000 – 2499 gm as well as 2500 – 2999 gm. Similar to child age, the sex of the children was observed to be significantly correlated $\left(\chi^2_{df=3} = 112.877, p < 0.001\right)$.

In terms of birth order, more children with higher birth orders had birth weights of 3000 g or higher, and as a result, lesser children with higher birth orders had birth weights of less than 3000 g or higher. In children under the age of five, birth order was found to significantly correlate $\left(\chi^2_{df=9} = 235.490, p < 0.001\right)$, much like age, with birth weight. According to Body Mass Index (BMI), 4.2% to 6.0% of under-5-year-old children with various BMI scores had birth weights under 2000 g, 9.2% to 17.6% had birth weights between 2000 g and 2499 g, 30.6% to 35.8% had birth weights between 2500 g and 2999 g, and 41.9% - 52.9% had birth-weight 3000 gm & more. Also, the percentage of children increased with increasing BMI scores. A significant correlation $\left(\chi^2_{df=9} = 295.533, p < 0.001\right)$ between BMI and birthweights of children under 5 years old was observed.

When taking into account the mother's highest level of education, 4.0% to 4.8% of children had birth weights less than 2000 g, 14.5% to 10.1% had birth weights between 2000 g and 2499 g, 29.4% to 37.6% had birth weights between 2500 and 2999 g, and 52.0% to 47.6% had birth weights of 3000 g or more. Further, the percentage of children belonging to different mothers' highest education level groups reduces as their education level increases for children having their birth-weight between 2000 and 2499 grams as well as 3000 gm & more. But this situation reverses for the birth-weight groups less than 2000 gm as well as 2500 – 2999 gm. The highest education level of the mother was significantly associated $\left(\chi^2_{df=9} = 117.226, p < 0.001\right)$ with children’s birth weight. Additionally, the analysis showed a significant relationship $\left(\chi^2_{df=9} = 29.329, p < 0.001\right)$ between the mother's occupation and children's birth weight when the mother's occupation was taken into account with under-5 children's birth weight.

The analysis also showed that the respondents' two characteristics, their type of place and wealth index, were significant in determining their birth weight. The findings showed that whereas 13.2% of urban and 14.3% of rural under-5 children had birth weights between 2000 and 2499 gm, 4.2% of urban and 4.5% of rural under-5 children had birth weights less than 2000 gm. For the birth-weight groups, 2500 – 2999 gm as well as 3000 gm & more, the percentage of under-5 children was more in urban areas than in rural areas. Types of the place were also significantly associated $\left(\chi^2_{df=3} = 9.640, p = 0.022\right)$ with children’s birth weight. Furthermore, when the wealth index was considered with under-5 children’s birth weight, the analysis revealed that the wealth index also had a significant associated $\left(\chi^2_{df=12} = 150.651, p < 0.001\right)$ with the children's birth weight.

4.6.7.1 Growth Estimation of Under-5 Children Using Statistical Model

The height and weight data of children under the age of five from the Western Region of India were fitted to all 11 statistical models, taking into account their ages (months) for each of the four birth-weight groups separately, in order to estimate the growth curves. In order to estimate the growth of boys and girls separately, our analysis showed that, when using the best-fit model criterion, only two statistical models—*Cubic Model* and *Power Model*—showed the best fit to the height and weight data of under-5-year-old children who fell into the various birth-weight categories. Here, the results of only two best-fit models have been shown below *(Tables 4.6.43 and 4.6.44).*

Table 4.6.43 describes the model summary for the height and weight of boys as well as girls by their birthweight categories. For the height of the boys, the *Cubic Model* here fit best for the birth-weight groups 2000 – 2499 gm ($R^2 = 0.781$), followed by group 2500 – 2999 gm ($R^2 = 0.768$), group 3000 gm & above ($R^2 = 0.766$) and less than 2000 gm ($R^2 = 0.757$), using the Coefficient of Determination (R^2) as the criterion for the best fit. For the height of girls, *Power Model* here fits best for the birth-weight group less than 2000 gm ($R^2 = 0.814$), followed by group 2500 - 299 gm ($R^2 = 0.756$). Thus, as per, Coefficient of Determination (R^2) *Cubic Model* fits best for the birth-weight group 2000 – 2499 gm ($R^2 = 0.761$), followed by group 3000 gm & above ($R^2 = 0.752$).

Table 4.6.43: Model's summary for Height of Boys & Girls by their Birthweight categories (West Region)

Birthweight	Model	R^2	Constant	d.f.		F	b_1	b_2	b_3
				Regression	Residuals				
Boys									
< 2000	Cubic	0.757	54.772	3	315	326.9	1.604	-0.025	0.0001
2000 - 2499	Cubic	0.781	55.273	3	1067	1269.9	1.668	-0.027	0.0002
2500 - 2999	Cubic	0.768	57.108	3	2857	2149.8	1.529	-0.023	0.0001
3000 +	Cubic	0.766	56.503	3	4357	4742.4	1.716	-0.030	0.0002
Girls									
< 2000	Power	0.814	46.008	1	358	1565.1	0.179		
2000 - 2499	Cubic	0.761	56.113	3	1170	1240.1	1.402	-0.018	0.0001
2500 - 2999	Power	0.756	47.774	1	2758	8528.3	0.174		
3000 +	Cubic	0.752	56.474	3	3627	3668.4	1.595	-0.026	0.0002

Table 4.6.44 describes the model summary for the weight of boys as well as girls by their birth-weight categories. *Power Model* fitted best for the weight of boys as well as girls. Further, considering boys, as per the Coefficient of Determinant (R^2), *Power Model* fits best for the birth-weight group 2000 – 2499 gm ($R^2 = 0.779$), followed by groups 2500 - 2999 ($R^2 = 0.753$), group 3000 gm & above ($R^2 = 0.722$) and group less than 2000 gm ($R^2 = 0.721$). For the weight of the girls, Power Model reveals the best fit to the birth-weight group less than 2000 gm ($R^2 = 0.778$), followed by group 2000 – 2499 gm ($R^2 = 0.763$), group 2500 – 2999 gm ($R^2 = 0.758$) and the group 3000 gm & above ($R^2 = 0.754$).

Table 4.6.44: Model's summary for Weight of Boys & Girls by Birthweight categories (West Region)

Birthweight	Model	R^2	Constant	d.f.		F	b_1
Boys				Regression	Residuals		
< 2000	Power	0.721	2971.668	1	318	822.769	0.363
2000 - 2499	Power	0.779	3330.337	1	1073	3668.997	0.341
2500 - 2999	Power	0.753	3570.768	1	2873	8758.087	0.327
3000 +	Power	0.722	3849.614	1	4363	11343.369	0.315
Girls							
< 2000	Power	0.778	3532.490	1	360	1260.978	0.396
2000 - 2499	Power	0.763	3116.702	1	1174	3782.449	0.351
2500 - 2999	Power	0.758	3232.799	1	2764	8634.262	0.345
3000 +	Power	0.754	3512.488	1	3645	11200.517	0.327

4.6.7.2 Height & Weight Curves for boys and girls in Western Region

Using the Cubic Model or Power Model, depending on which best fit the situations, we estimated growth values for boys and girls separately, taking into account the mean height and weight of under-5-year-old children for their ages ranging from 1 to 59 months, considering all four birth-weight groups. As a result, growth charts were created for each of the birth-weight groups as well as for the two sexes separately using mean height and mean weight curves. For each of the four birth-weight groups separately, *Figures 4.6.5(a) to 4.6.5(d)* show the estimated mean height and mean weight curves of boys. Similarly, estimated mean height and mean weight of girls are shown separately for each of the four birth-weight groups in *Figures 4.6.6(a) to 4.6.6(d).* The graphs displayed here include curves for both the upper and lower 95% confidence limits in addition to estimated mean height and weight curves for each case.

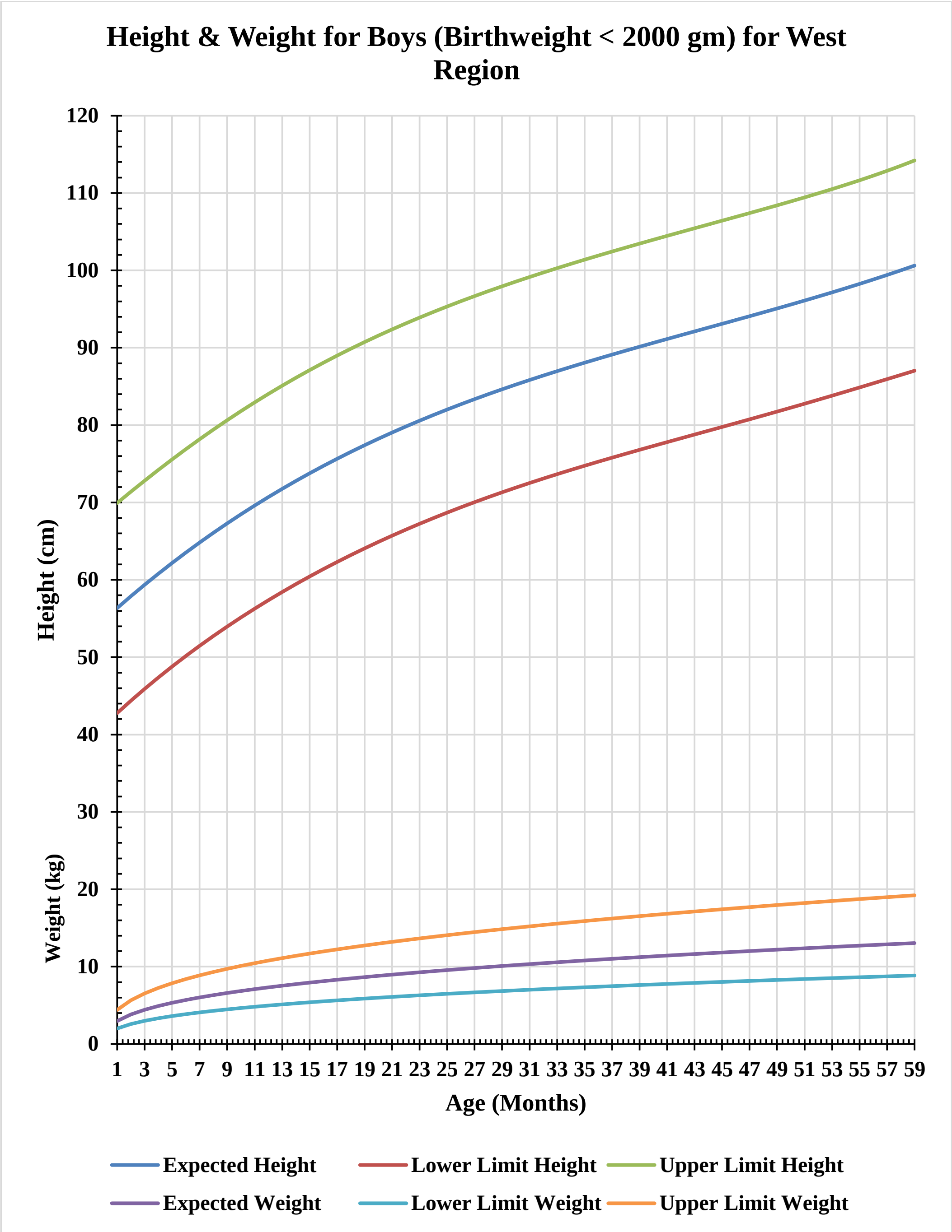
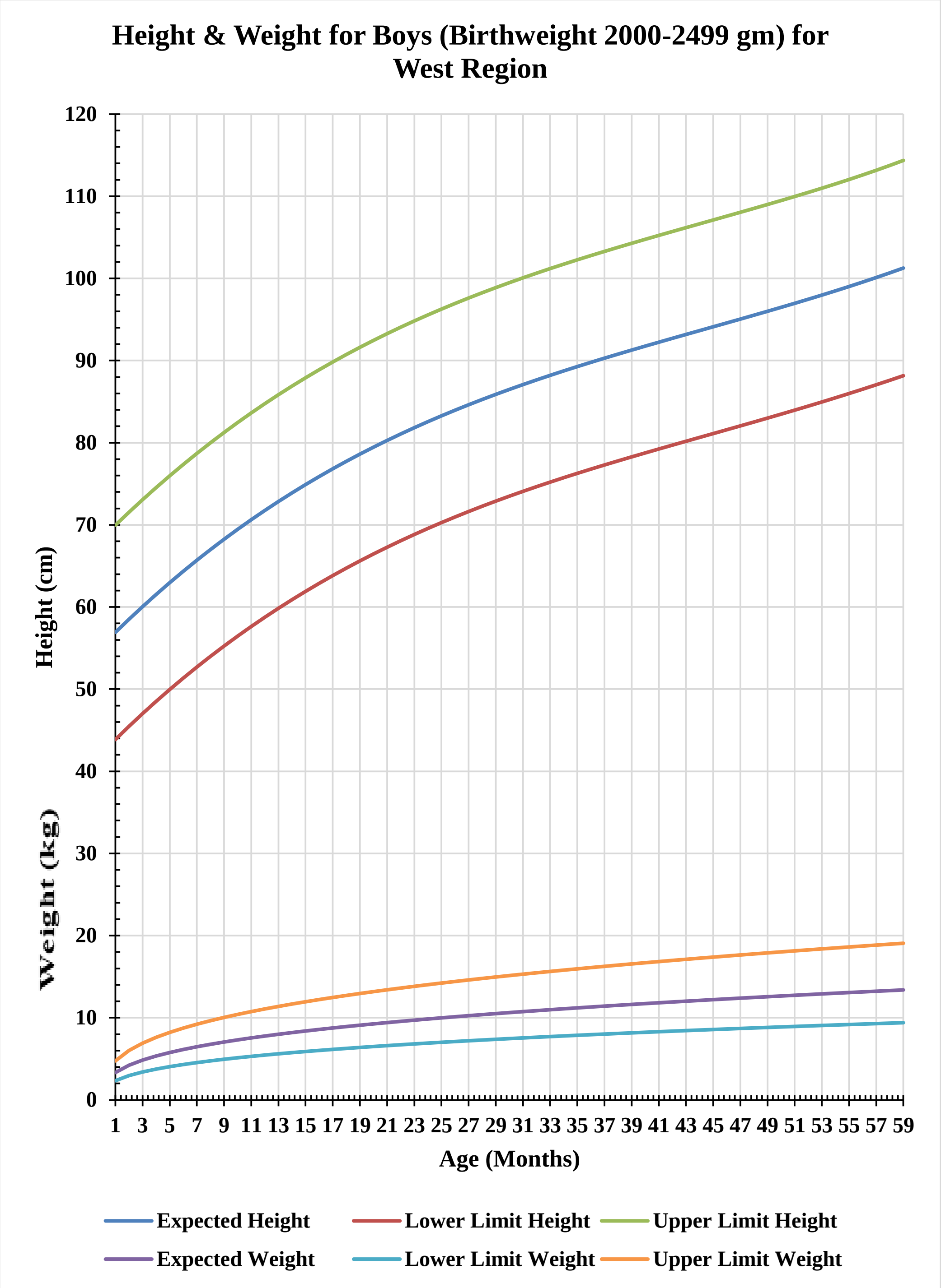
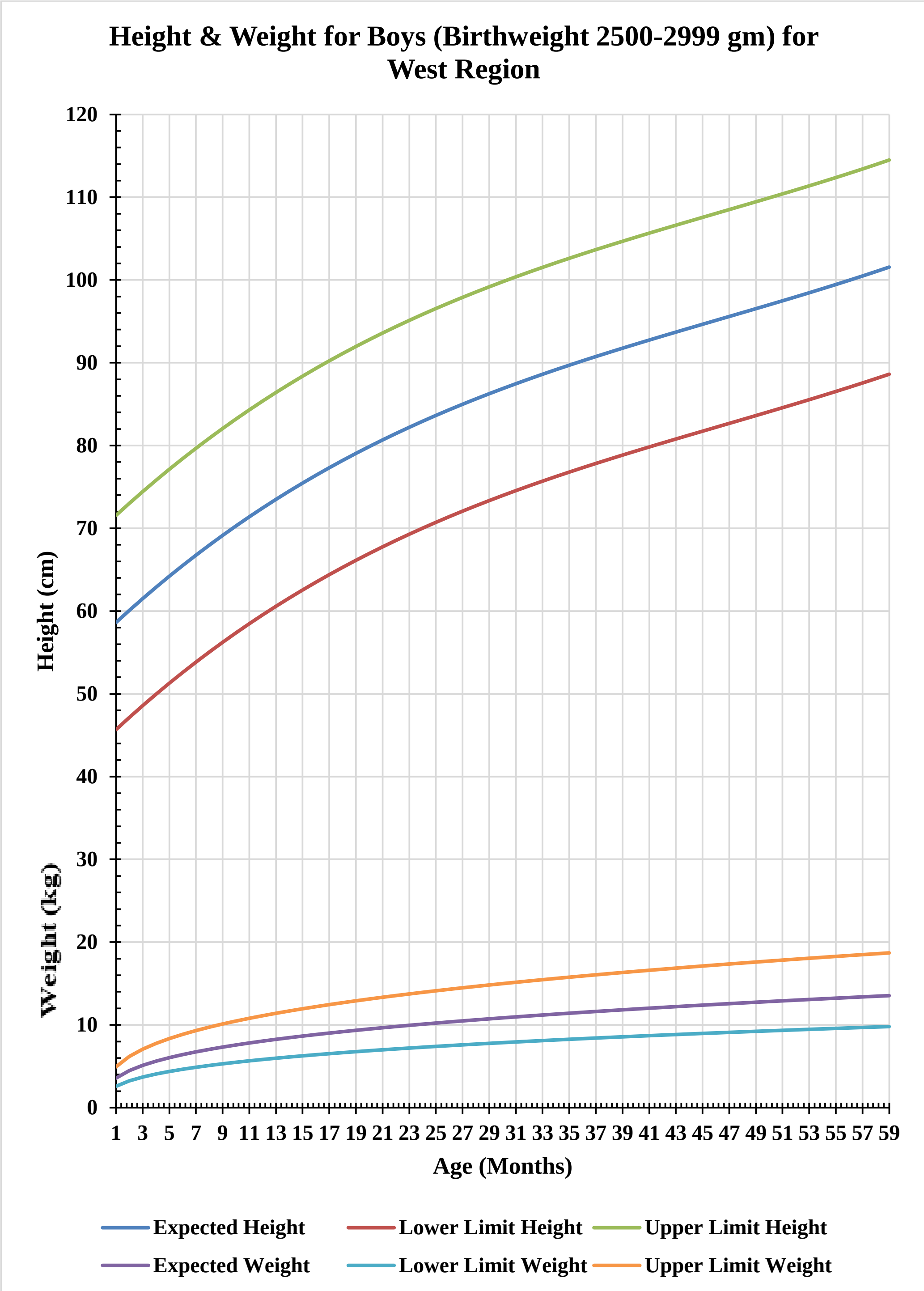


Figure 4.6.5(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Boys of West Region (India), Using Cubic and Power Model, respectively



$Figure$ 4.6.5(b): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Boys of West Region (India), Using Cubic and Power Model, respectively



$Figure\ 4.6.5(c)$: NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Boys of West Region (India), Using Cubic and Power Model, respectively

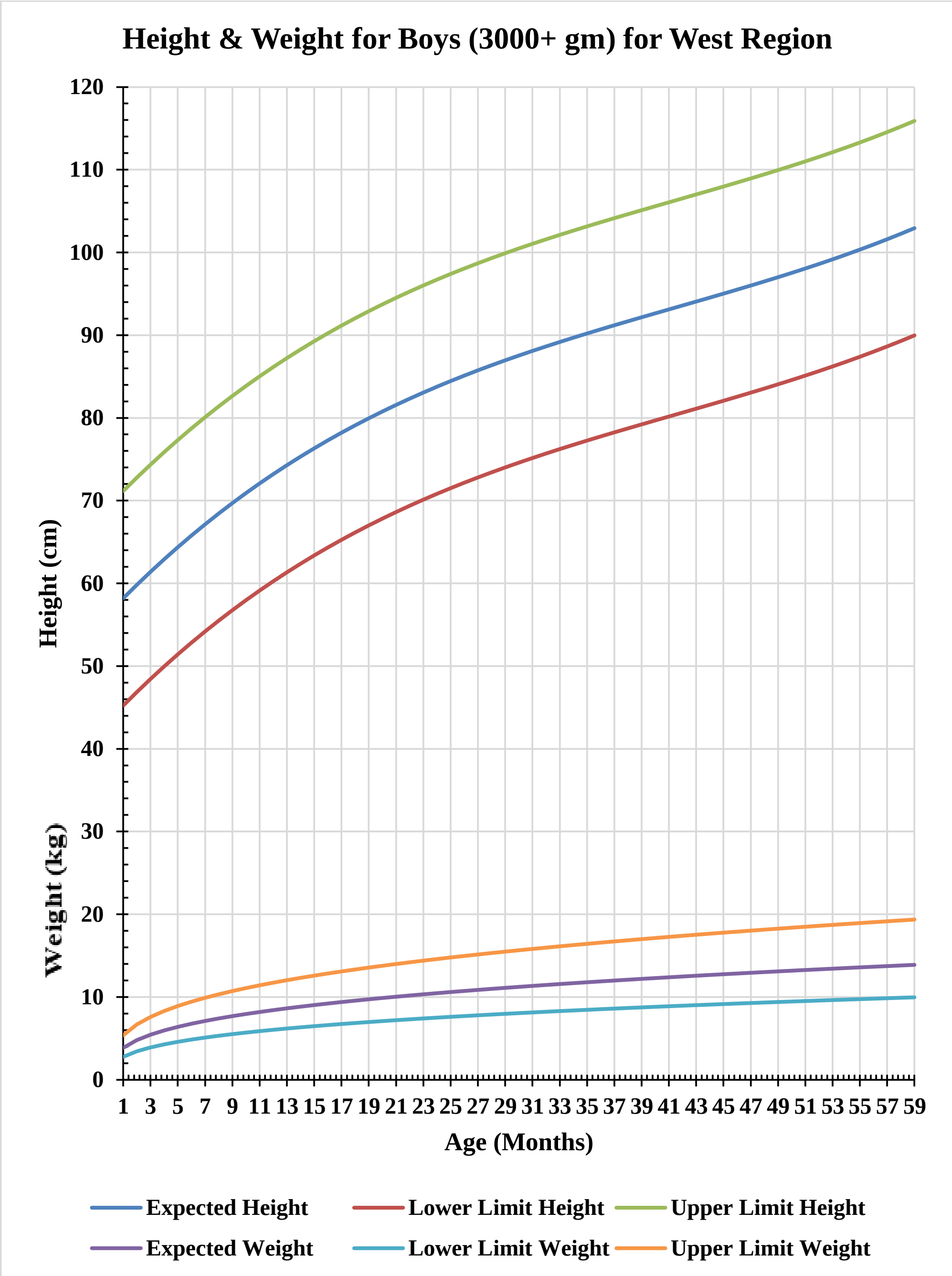


Figure 4.6.5(*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Boys of West Region (India), Using Cubic and Power Model, respectively

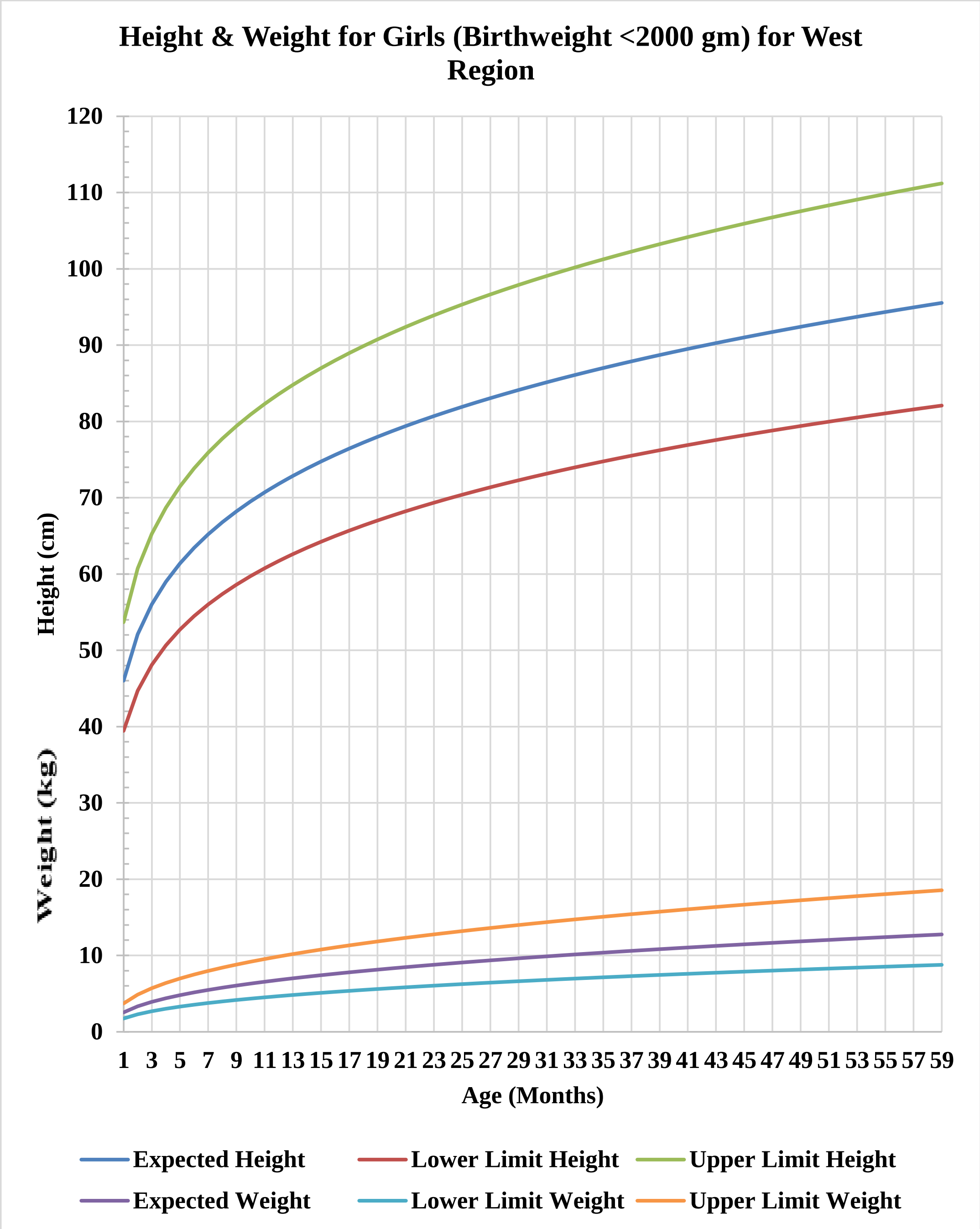


Figure 4.6.6(*a*): NFHS-4 (Birth-weight <2000 gm): Estimated Height & Weight Curves for Girls of West Region (India), Using Power Model

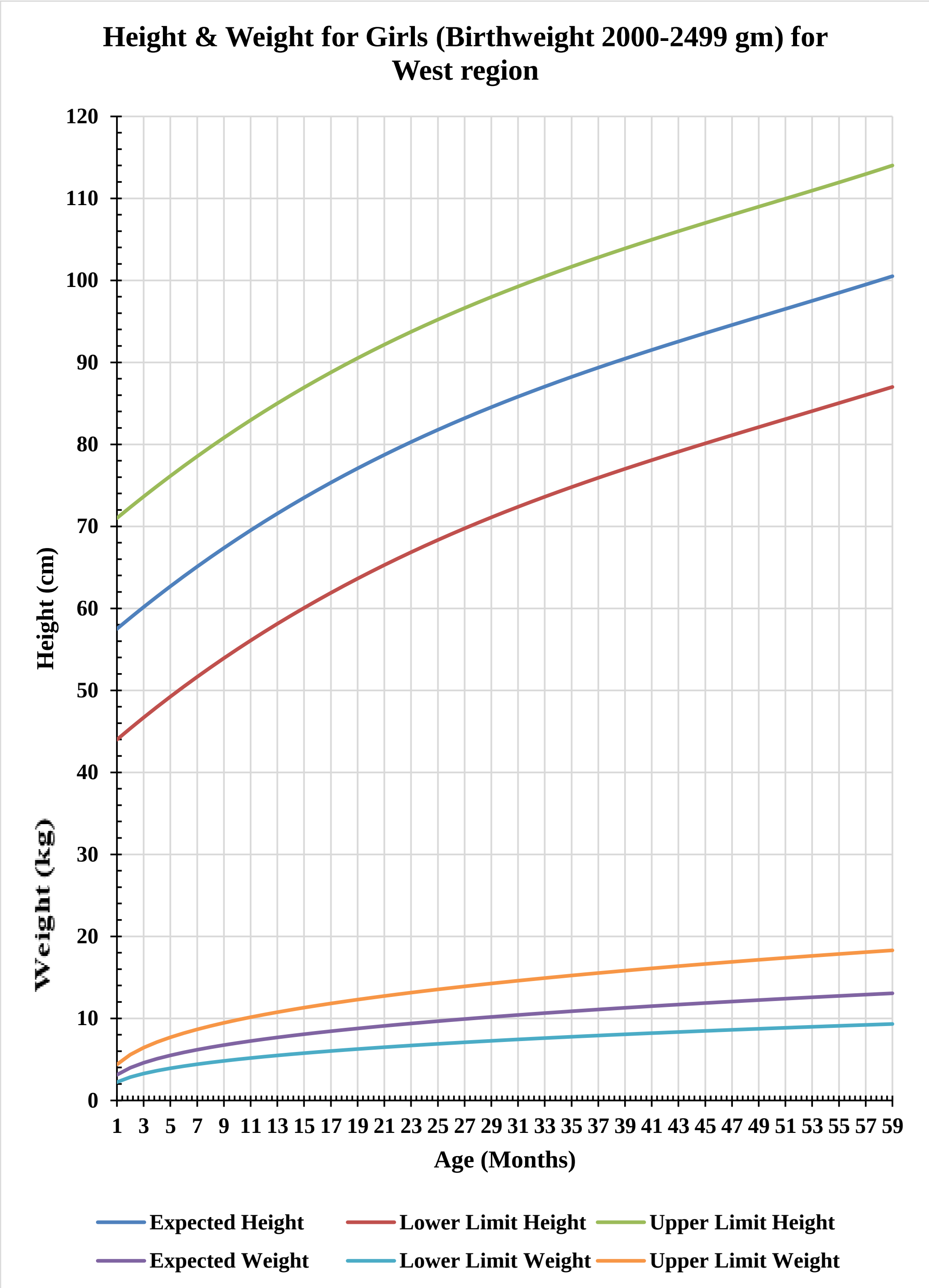
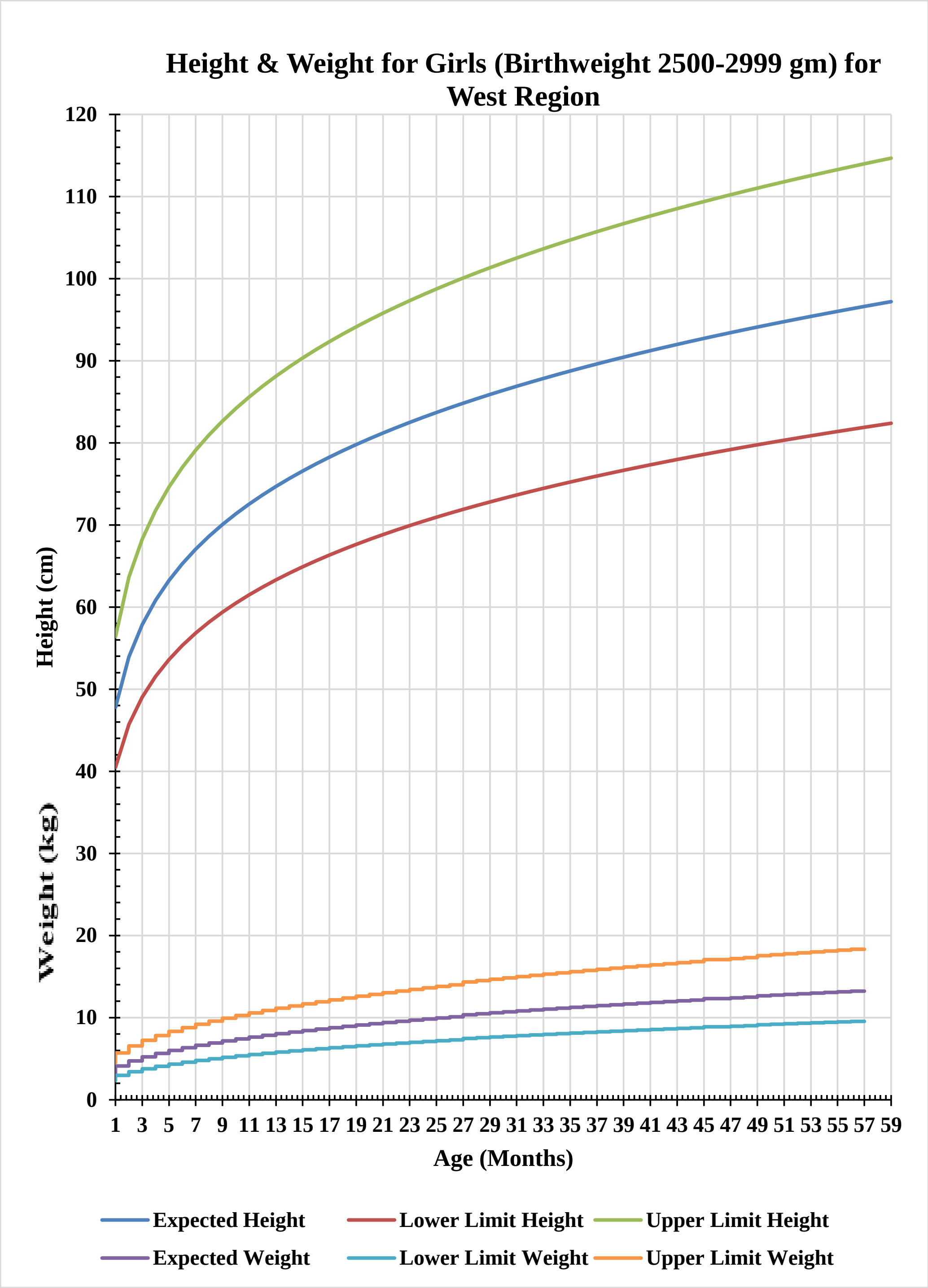


Figure 4.6.6(*b*): NFHS-4 (Birth-weight 2000 - 2499 gm): Estimated Height & Weight Curves for Girls of West Region (India), Using Cubic and Power Model, respectively



$Figure\ 4.6.6(c)$: NFHS-4 (Birth-weight 2500 - 2999 gm): Estimated Height & Weight Curves for Girls of West Region (India), Using Power Model

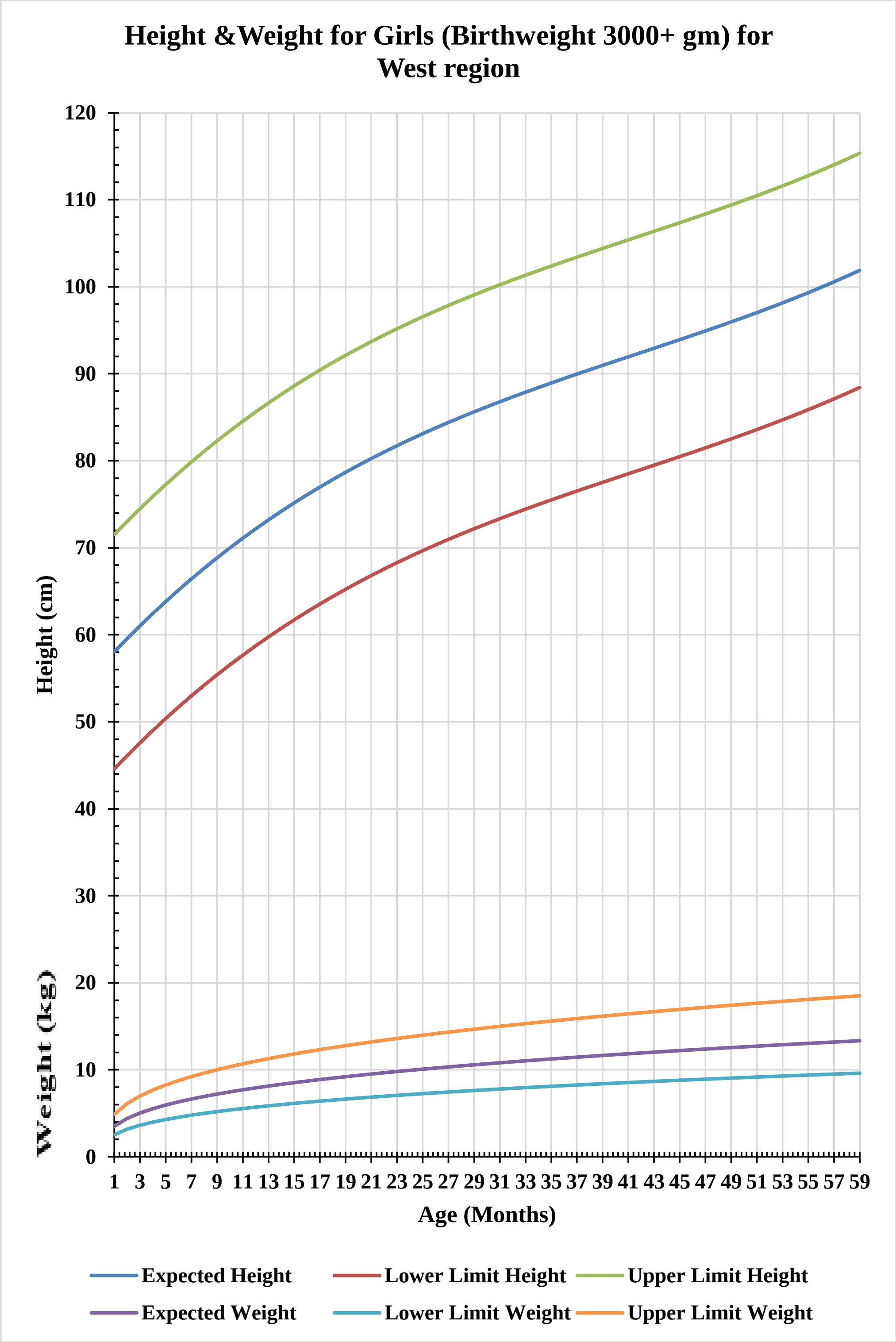


Figure 4.6.6(*d*): NFHS-4 (Birth-weight 3000+ gm): Estimated Height & Weight Curves for Girls of West Region (India), Using Cubic and Power Model, respectively

5. DISCUSSION

Malnutrition is the country's serious health issue; however, studies on the growth dynamics of children below the age of 5, using advanced biostatistical methods, such as - statistical models, are lacking. As a result, neither better estimates of measurements of under-nutrition, such as - stunting, wasting, underweight, and overweight, in Indian children, nor the precise contributions of its major risk factors are known. The current study provides reliable estimates of growth measures and nomograms for the height and weight of the under-five children of the nation by utilizing appropriate statistical models. The study is projected to help healthcare planners and mothers of children under the age of five in the nation for a better, more comprehensive future.

Assessment of nutritional status and identification of growth failure, using anthropometric measurements, like height & weight is dome using Nomograms (also, called Growth Charts). Growth Charts are of two types - *Growth Standards* and *Growth References* (Khalidar and Khalidar, 2021)[47]. Advantage of having Growth Standards, like the World Health Organization Standards (2006) is that children of different races & countries can be compared - using a single Standard and thus comparison becomes quite simple. The Growth References are the trues representatives of existing nutritional pattern of the children. These Growth References however, need to be updated from time to time. Without having appropriate Growth Nomograms, is not possible to measure under-nutrition, namely stunting wasting & under-weight as well as over-weight & obesity. Quite often, State References or the Regional References (where 2-3 or more States are clubbed together) are no available, thus providing hurdles for measuring the malnutrition status of children. This is true, particularly for our country. This Study gives the Region-Specific-Nomograms that are appropriate and would be quite useful for measuring the status of malnutrition – applying anthropometric measurements, in under 5 children.

For the present study, a kid's file of NFHS-4 has been used by us which covers 2,59,627 children, to study the growth dynamics of under 5 children in the Indian Region. As per NFHS–4, we have suitably divided India into 6 Regions, viz. - Central Region, Eastern Region, Northern Region, Northeast Region, Western Region, and Southern Region. The Logistic Regression Model and Generalized Linear Model were applied to study growth dynamics and major determinants of under-nutrition in under-5 Indian children in the present Study. Further, after critically reviewing the 11 existing statistical models available in the SPSS statistical software, the two statistical models, namely - *Power Model and Cubic Model,* which were identified to be the most appropriate under different situations, were applied to bring-forth Growth Nomograms of height and weight against age, considering 4 different birth-weight categories for the two sexes separately.

5.1 Status of Under Nutrition in Under–5 Children in India

The status of under-nutrition in the present study was studied in terms of stunting, wasting and underweight by computing prevalence rates (%). Out of these 3 under-nourished conditions in different Regions, highest prevalence rate was seen for stunting (38.4 %) in Central Region, followed by under-weight (37.4%) in Eastern Region and then wasting (22.3 %) in Western Region. Stunting in our Study, ranged between 2.9.5% and 38.4%. The under-weight ranged between 18.4% and 37.4%. Similarly, wasting ranged between 11.3% and 22.3%. Thus, stunting was founding to be the biggest public health problem in the country and the burst affected Region which included 3 countries – Chhattisgarh, Madhya Pradesh, and Uttar Pradesh, was Central Region. The second worst mal-nourished condition in the country, in order, was under-weight (37.4%) and the second worst affected Region which included 4 countries – Bihar, Jharkhand, Odisha and West Bengal, was the Eastern Region.

However, Wondimagegn (2014) demonstrated highest prevalence rate of stunting in South African country[53]. In 4 localities of River Nile State in North Sudan, a Cross–Sectional Household Survey, conducted by Sulaiman et al (2018) in which 1,635 children under the age of 5 years had taken part, reported similar order of prevalence rates of stunting (42.5%), underweight (32.7%) and wasting (21.0%)[8]. A Systematic Review and Meta Analysis of studies on HIV positive children in East Africa found that prevalence of stunting was highest (49.8%), followed by under-weight (41.3%) and then wasting (24%)[10]. Similarly, Li et al (2020) used data from Demographic and Health Surveys from 35 LMICs to conduct a cross-sectional study of 2, 99,353 children who were born singletons and were aged 12 to 59 months. Analysis showed that 38.8% had stunting, 27.5% had underweight and 12.9% had wasting. Thus, our results on the status of stunting, wasting and underweight are in line with several studies conducted abroad on the subject[11].

In India also, series of studies measuring extent of problem of mal-nutrition in under 5 children, under different situations are available[59, 60, 61, 62, 65, 67]. Meshram et al, (2012a) in their Study on malnutrition in children, aged 1-5 years, conducted in a trial area of Maharashtra**,** found a high prevalence of stunting as well as of under-weight (ranging between 61% and 64%) and 29% as the prevalence of wasting[59]. In their another Study on the subject (Meshram et al, 2012b), these prevalence rates were 51%

for stunting, 49% for underweight and 22% for wasting[60]. In a review article from India Sahu et al (2015) who gathered data on malnutrition in under 5 children, from Google Search, Medline & some other sources showed that this prevalence varied widely from area to area, depending upon the method of assessment (39-75% for underweight, 15.4 – 74% for stunting and 10.5 - 42.3% for wasting)[61]. Rajaram et al (2016) found that 44% of the under 5 children were stunted, 37% were underweight and 18 % were wasted[62]. In another Study on under nutrition in children below 2 years of age in urban slums of Pune (Maharashtra), authors, in a sample of 400 children, found prevalence of stunting to be 34.0%, wasting 15.3% and underweight 21.8%. In the light of above observations, it is amply clear that our results on the status of under-nutrition match with some other available Indian studies as regards order as well as of extent of problem of under nutrition in the country is concerned[65].

5.2 Studying Growth Dynamics of Under 5 Children in terms of Stunting, Wasting & Under-Weight in Relation to their Major Determinants in Different Indian Regions

In the present work, *Logistic Regression Model* was applied to study the major determinants of stunting, wasting and under-weight of boys of girls, under 5, in different geographical Regions of the country. Several socio–demographic variables, namely - child age (in months), child sex, wealth index, mothers' education level, type of residence, birth order and body mass index (BMI) were found to be significantly associated with stunting in the Central Region, Northeast Region, Northern Region, and Southern Region. But, in Eastern Region, except for child sex and type of residence, all other above socio–demographic factors were statistically significant whereas in Western Region, except for type of residence, all socio –

demographic factors, were found to be statistically significant as regards their association with stunting.

Similarly, out of 7 socio – demographic variables, only 6 variables, namely – child age (in months), child sex, BMI, education level, type of residence and wealth index were found to be significantly associated with wasting in Central Region, Northern Region, and Southern Region. In Eastern Region however, except education level, all other variables were statistically significant to wasting. For Northeast Region, all above socio – demographic variables were statistically significant to wasting but, for Western Region, except education level, type of residence and birth order, only child age, child sex, wealth index and BMI were found to be significantly associated to the wasting.

For underweight also, all socio-demographic variables, namely – child sex and age, birth order, BMI, education level, type of residence and wealth index found statistically significant in the Central Region, Northern Region, and Southern Region. For Eastern Region, except for child sex, all other above socio – demographic variables found to be statistically significant to the underweight. But, for Northeast Region and Western Region, except for type of residence, all other above socio – demographic variables found to be significantly associated to the underweight

Meshram et al. (2012a) revealed that there was a significant reduction in the prevalence of underweight and stunting over two time periods (1999 and 2008). They also showed that the risk of underweight was 1.7 times higher among children of illiterate mothers and those suffering from morbidities, while stunting was 1.4 times higher among children belonging to lowest and middle household's wealth indexes[59]. Meshram et al (2014) revealed that the risk of underweight and stunting was, respectively, 1.9 and 2.4 times higher among children of illiterate mothers, whereas underweight and wasting was 1.4 times higher among children who had morbidities during the preceding fortnight. The prevalence of under-nutrition was significantly higher during monsoon as compared to the winter season. In order to evaluate nutritional condition of 1,951 preschool children in terms of underweight, stunting, and wasting as well as their correlates and seasonal variations in nutritional status[77].

Chowdhary et al (2016) using Chi - Square test and Multilevel Logistic Regression Analysis found that the variables, viz. - age, sex, mother's Body Mass Index, mother's educational status, father's educational status, place of residence, socioeconomic status, community status, religion, region of residence, and food security were significant factors of the child malnutrition. Children with poor socio-economic and community status were at higher risk of malnutrition. Children from food insecure families were more likely to be malnourished[70]. Similarly, Das and Gulshan (2017) in their Study found that odds of being stunted were 30% to 50% higher in Sylhet Division as compared to other Divisions. Other key covariates for stunting were urban area, no or primary education of father, no or primary education of mother, underweight mothers and wealth index poorest. Important covariates for wasting were mother’s occupation as physical labour, underweight mothers, and wealth index poorest. For underweight, main covariates were no or primary education of father, no or primary education of mother, mothers in physical labour, underweight mothers, and wealth index poorest[2].

Akombi et al (2017) found that using Multivariable Analysis which revealed that the most consistent factors associated with wasting / severe wasting and underweight / severe underweight were geopolitical zone (North East, North West and

North Central), perceived birth size (small and average), sex of child (male), place / mode of delivery (home delivery and non-caesarean) and a contraction of fever in the two weeks prior to the survey[5]. Hagos et al (2017) in their Study identified statistically significant clusters of high prevalence of stunting (hotspots) in the Eastern part of the district and clusters of low prevalence (cold spots) in the Western part. They found that the inclusion of spatial structure of the data into the Bayesian model showed improved fit for stunting model. The Bayesian geo-statistical model indicated that the risk of stunting increased as the child's age increased among boys. However, maternal education and household food security were found to be protective variables against stunting and severe stunting[23].

Sulaiman et al (2018) conducted a Cross-Sectional Household Survey across four localities in River Nile State of North Sudan. They discovered that 42.5% of the 1,447 surveyed children, suffered from stunting. The age group of 48 to 60 months experienced the highest level of stunting. Geographically, the prevalence of stunting was higher in the Berber Region. Children, aged 48-60 months had the greatest likelihood (50.55%) of being under-weight. The significant statistical association of wasting was observed with report of recent illness mainly gastroenteritis and respiratory illness[8]. Akhade et al (2019) revealed that family size, initiation of breastfeeding, maternal education, underweight mothers, and maternal dietary intake are significantly associated with underweight children. Similarly, stunted children show strong association with increasing age of child, birth weight, and not seeking medical opinion. Primary immunization, maternal education, employed mothers, and underweight mothers are associated with wasting in children[71]. Agho et al (2019), in their Study found, that after adjusting for potential confounding factors, the odds of a child being stunted were higher in Gicumbi District in Rwanda while the odds of a child being wasted and underweight were higher in Kitgum District in Uganda. Wealth index (least poor household), increasing child's age, sex of the child (male) and unavailability of water all the year, were reported to be associated with moderate or severe stunting / wasting. Children of women who did not attend Monthly Child Growth Monitoring Sessions and children who had Acute Respiratory Infection (ARI) symptoms were significantly associated with moderate or severe underweight[9].

Khan et al (2019) in their Study found that children whose mothers lived in rural areas, were aged ≥18 years at marriage and had visited antenatal clinic more than 3 times during pregnancy were less likely to be stunted. Mother's low educational level, short stature, child's small size at birth and mother's BMI were significantly associated with child's underweight status. Children whose mothers had no education were more likely to be wasted[12]. Takele et al (2019) in their Study found that age and sex of the child, preceding birth interval, mother's Body Mass Index, household wealth index, mother's education level, breastfeeding period, type of toilet facility, use of internet and source of drinking water were the major determinants of stunting[22].

In a similar way, Li et al (2020) found that in the pooled sample, short maternal height was the strongest factor, associated with child stunting, followed by lack of maternal education, poorest household wealth and low maternal Body Mass Index. Short paternal height was also significantly associated with higher odds of stunting. Consistent results were found for underweight (e.g., short maternal height; lack of maternal education) and wasting (e.g., low maternal Body Mass Index, poorest household wealth). Other factors were not associated with anthropometric failures in pooled analysis and had large country-level heterogeneity (for example, unsafe water was not associated with child underweight in the pooled analysis)[11]. In another Study, Mengesha et al (2020) revealed that children, aged 24 months to 59 months were at 9.71 times higher risk of being stunted compared to their younger counterparts, aged 6–24 months. Those children weighing below 9.1 kg were at 27.86 odds of being stunted compared to those weighing 23.3 kg and above. Moreover, mothers with a height below 150 cm, living in a rural area, and being a male were the factors associated with stunting[24].

Hailu at al. (2020) found that male children, multiple births, older children, and anaemic children were severely stunted at individual-level factors. Children from educated and malnourished mothers and from less wealthier mothers were severely stunted at household-level factors[57]. Gebremeskel et al (2022) revealed that children, aged 36-47 months and 48-59 months, girls, smaller-than-average birth weight and very small birth weight were the individual-level factors associated with wasting, whereas husband's educational status was the significant household-level factor. Somalia, Southern Nations Nationalities & People (SNNP), and Addis Ababa regions were the community-level factors associated with child wasting[28]. Moshi et al (2022) revealed that risk factors for underweight children were - child's gender, age, birth weight, mothers' BMI, level of education and type of toilet facility, used by the households. Females had a significantly lower risk of being underweight compared with male children. The odds of being underweight increased with low birth weight, low mother's BMI, and low educational level[32].

Goson et al (2022) revealed that, out of the 11,313 NGZ children below 60 months old, 24-59-month-old children recorded the highest prevalence for under-weight (34.8%). Four factors, consistently and significantly found to be related to the underweight-prevalence in children across the three age groups, were - poor or average-income households, maternal height, children who had diarrhoea episodes and children living in the Northeast or Northwest[33]. Similarly, Tesfaw and Dessie (2022) found that among 5,027 children considered in this Study 36% were stunted. The estimated odds of children from households with secondary & above education levels being stunted were 49. 60% (OR = 0.496) times the estimated odds of children from households with no education. Whereas children from the richest households were less likely to be stunted as compared to children from the poorest households (OR = 0.485). The estimated odds of children from urban areas being underweight and wasting were lower by 24.9% and 33.7% of estimated odds of children from rural areas respectively[14]. Also, Anuradha et al (2023) r**e**vealed that there was a greater reduction in stunting (from 54% to 38%, $p < 0.05$) than in underweight (from 44% to 34%, $p < 0.05$) and wasting (from 19% to 20%, $p > 0.1$) status over the period of 4 NFHS rounds from 1992 to 2016. In line with this, combination of improved height for age (-2.1 ± 1.8 to -1.5 ± 1.7) but relatively less improved weight for age (-1.8 ± 1.4 to -1.5 ± 1.2), the change in wasting status was either nil or meagre (-0.8 ± 1.4 to -0.9 ± 1.4). The percentage of children, malnourished by all 3 indicators together reduced from 9% to 6% ($p < 0.05$)[73].

5.3 Studying Major Determinants of Growth in Under 5 Children of Different Indian Regions

In the present work, *Generalized Linear Model* was applied for estimating two factors, such as – child sex & age, birth order, education level, wealth index, and BMI in Central Region, Eastern Region, Southern Region and Western Region, whereas child sex and age, education level, type of residence, wealth index and BMI in

Northern Region were statistically significant to the child weight. Similarly, in the Northeast Region, factors, viz. -child age and sex, education level, wealth index, and BMI were significantly associated with child weight.

Factors – child sex, birth order, education level, respondent occupation, wealth index, and BMI were statistically significant to child height in the *Central Region*. However, in the *Eastern Region* and *Northern Region* variables, such as – child sex, education level, wealth index, and BMI were found significant to child height. In the Northeast Region, factors, viz. – birth order, respondent's occupation, wealth index, BMI, and child sex, whereas, in the Southern Region, factors, viz.– education level, wealth index, and child sex were significant the child height. Similarly in the Western Region factors, namely – birth order, education level, type or residence, wealth index, and child sex were significant to the child height.

Our study also indicates that for the Central and Eastern Region, socio–demographic variables, namely – age and sex of a child, birth order and BMI and education status, place of residency, and wealth index were significantly associated with birth weight. In the Northeast Region, child age, birth order, BMI, education level, type of residency, and wealth index were significantly associated to the birth weight. But, for the Northern Region, Southern Region, and Western Region factors, namely- child age and sex, birth order, BMI, education level, respondent's occupation, type of residency, and wealth index were significantly associated with birth – weight.

To evaluate the nutritional condition of 1,751 preschoolers in tribal parts of Maharashtra, Meshram et al (2012), applied Bivariate Logistic Regression Analysis to investigate the relationship between the dependent variable of under-nutrition and its factors. To find the most effective collection of variables, influencing individual risk factors for under-nutrition, Stepwise Logistic Regression was performed[59]. Corsi et al (2016) used National Family Health Survey's -Third Round (NFHS-3) Data, for studying malnutrition in children, aged 6-59 months. They used two Logistic Regression Models to evaluate the relationships between risk variables and child anthropometric measurements[35]. Akombi et al (2017), in a sample of 24,529 children, aged 0–59 months from the 2013 Nigeria Demographic and Health Survey (NDHS) Data studied malnutrition. The authors applied Multilevel Logistic Regression Analysis that adjusted for cluster and survey weights to identify significant factors associated with wasting / severe wasting and underweight / severe underweight[5].

Das and Gulshan (2017) in their Study used data from Bangladesh Demographic Health Survey-2014. They assessed the association between the selected factors and nutritional status by applying Logistic Regression Models for the three indicators - stunting, wasting and underweight[2]. In their Study, Chowdhary et al (2016) extracted data from the Bangladesh Demographic Health Survey – 2011 and used Chi-square analysis to determine the relationships between outcome variables and particular factors. They then used Multilevel Logistic Regression Models with random intercepts at the household and community levels to determine the risk factors for stunting, wasting, and underweight. Using data from the 2015-2016 National Family Health Survey, in which primary analysis included 140,444 children, aged 6–59 months[70]. Kim et al (2019) analyzed each correlate -first individually in age and sex-adjusted models, followed by jointly, in a mutually adjusted model, and then applied Logistic Regression Analysis to study the malnutrition[36]. Ghosh and Varerkar (2019) performed a Study among 375 tribal households with children between the ages of 1 and 6 years. To investigate the independent impacts of predictor variables on stunting, wasting and underweight, they applied Multivariate Logistic Regression Models to their data[25]. In their study, Khan et al (2019) included a sample of 3,071 Pakistani children who were between the ages of 0 and 59 months. They looked at the relationships between a few maternal-socio-demographic and child-level characteristics and three proxy measures of child's nutritional health status, using Uni and Multivariate Binary Logistic Regressions[12].

Agho et al (2019) used Cross-Sectional Surveys from Rwanda, Uganda, and Tanzania to investigate data for 9,270 children, aged 0-59 months. The causes of under-nutrition among children were identified, using Generalized Linear Latent and Mixed Models, using the mlogit link and binomial family that corrected for clustering and sampling weights[9]. In their research, Tesfaw and Dessie (2022) used information from the 2019 Ethiopia Mini Demographic and Health Survey, which included a total of 5,027 under-five children. Given their correlation with anthropometric measures and clustering effect, a Multilevel Multivariate Logistic Regression Model was used by the authors to quantify the influence of the determinants[14]. Takele et al (2019) extracted data from Ethiopian Demographic and Health Survey - 2016. In order to determine socioeconomic, demographic, environmental, and health-related risk variables for stunted under-five children, they used Generalized Linear Mixed Model - an extension of the Generalized Linear Model[22]. Hagos et al (2017) carried out a Cross-Sectional Survey in the community to count the number of stunted and severely stunted children. They used a Bayesian Geo-Statistical Model, which took into account the spatial dependency structure in the data, to identify potential risk factors for stunting in the Study area. Finally, they applied Local Anselin Moran's I to investigate the spatial variation of stunting prevalence and identified potential local pockets (hotspots) of its high prevalence[23].

Mengesha et al (2020) in their research, analyzed data from the 2016 Ethiopian Demographic Health Survey, which included 7,909 children between the ages of 6 and 59 months. They applied Bivariate and Multivariable Logistic Regression[24]. Hailu et al (2020) used information from the Ethiopian Demographic and Health Survey- 2016 and included 9,588 children between the ages of 0 and 59 months. To investigate regional heterogeneity and also to highlight individual and household-level characteristics related to stunting and severe stunting, they used Spatial and Multilevel Logistic Regression Analysis[57].

Gebremeskel et al (2022) in their Study, obtained data from Ethiopia Demographic and Health Survey-2016. They applied Multilevel Logistic Regression Model[28]. A secondary data Study was carried out on a sample of 4,327 infants, aged 0-23 months by Moshi et al (2022), using information from the Tanzania Demographic and Health Survey 2015-2016, applied statistical techniques - both descriptive and inferential, including Multivariate Logistic Regression and Chi-Square to study some aspects of malnutrition[32]. Goson et al (2022) used Multilevel Logistic Regression to analyze a data-set of 33,776 live births from the Nigeria Demographic and Health Survey between, 2008 – 2018. This dataset was used to assess the characteristics related to the prevalence of under-weight in children aged 0-23, 24-59, and 0-59 months[19]. The data were gathered by Fenta et al (2020) from the Ethiopian Demographic and Health Surveys (2000, 2005, 2011 and 2016), which included 27,564 under-five children from various regions of Ethiopia. They used Multivariate decomposition to identify patterns and identify the child, maternal, and household factors that were related to underweight whereas Logistic Regression Analysis was employed for each Survey to find out significant causes of underweight[34].

5.3 Child Growth Nomograms for Under-5 Children in Various Indian Regions

For estimating, Growth Nomograms against ages for 4 birth-weight categories and for each of the geographical Regions separately, eleven statistical models – in the SPSS Software Statistical Software, namely – Linear Model, Logarithmic Model, Inverse Model, Quadratic Model, Cubic Model, Compound Model, Power Model, S Model, Growth Model Exponential Model and Logistic Model were first critically reviewed and those showing best-fit to the data, based on the highest value of Coefficient of Determination (R^2) were decided to be applied for the purpose. Our analysis later, showed that out of these 11 statistical models, only two models – *Cubic Model* and *Power Model* showed best fit to the data for various birth weight categories. As such, these models were applied for estimating height and weight values, against ages for above children for each of the geographical Regions of the country, separately. Results of the present work, based on these models have been presented in the Chapter 4.

Inadequate growth throughout childhood has a negative impact on subsequent health consequences. The needs of the child's growth should be monitored by the family and a child expert. It is also used as a health indicator, and its secular trend shows how well the population is doing. India is in a nutritional transition phase; hence it is crucial for the nation to have current growth standards. 'Growth Standards' and 'Growth References' are frequently used while examining the growth of children. These two names refer to different ideas. Growth standards specify how a population of children should develop given ideal nutrition and health, whereas "growth references" are always descriptive and prepared from a population that is believed to be developing in the ideal nutritional and physical condition in a given community[47].

Additionally, children's growth patterns alter over time, therefore references to their growth should be updated frequently. In addition, comparisons of children's growth patterns with relevant anthropometric measurements from the available growth references are required for an accurate assessment of their growth patterns.

The growth references, quite often, are the children of the same age & sex from the well-to-do families either from the same or the national population. However, these comparisons are occasionally conducted using growth standards like the WHO when the appropriate local or national growth benchmarks are not available. Based on the Multicenter Growth Reference Study (MGRS), the WHO updated its growth and development guidelines for children under the age of five as well as for school-age children and adolescents in 2006/2007[36]. According to this standard, it was discovered that close to 30% of preschoolers in Developing Countries had stunted growth as a result of regional environmental variables, including poor nutrition and diseases[38]. The second leading cause of child mortality, child development failure accounts for more than 23% of deaths among children under the age of five in the Region[37].

Birth weight is frequently seen as a significant predictor of a child's health trajectory. It has been discovered to be a predictor of Protein Energy Malnutrition (PEM)[79]. Birth weight is also regarded as the single most important factor in determining a newborn's chances of surviving as well as for good growth and development. In our Study, we examined the relationship between specific socio-demographic characteristics and birth weight of the under-five children of the various regions of India using data from the National Family Health Survey-4. Our findings showed that seven out of the eight sociodemographic factors—namely, child's age and gender, birth order, BMI, mother's education level, place of residence, and wealth index—were significantly associated in Central as well as Eastern Region. In North Region, South Region as well as West Region, all eight socio-demographic factors have been statistically significant. But, in Northeast Region, six out of eight socio-demographic factors have been statistically significant.

Borah and Agrawal (2016) in their Cross-Sectional Study, undertaken in a Rural Block of Assam in India - based on their 450 randomly selected infants from 30 villages, found illiterate - teenage mothers, grand multi-para, short inter-pregnancy intervals and anaemic mothers to be the important risk factors of the low birthweight[78]. Similarly, another study by Mishra et al.[80] tested a hypothesis of no association between socio-economic status of households and new-borns' low birth-weight in India. The Study demonstrated that under-weight & rural women and women with no or primary education, low BMI, unclean cooking fuel and those from Northern & Eastern Region of the country had higher share of low birth-weight. This Study also revealed that female children, children of the 4th birth-order & with birth intervals of less than 24 months and those with no improved toilet facility had greater share of low birth-weight than their counterparts.

Statistical Growth Modelling Approach is a powerful tool for the studying growth of the children and their growth trajectories. It consists of fitting models to physical growth data (such as – weight & height) to obtain appropriate growth curves. Our results showed that only two models, viz. *Cubic Model* and *Power Model*, out of the 11 basic statistical models applied to the data, demonstrated best-fit to the height & weight data of under 5 children, belonging to the different birth-weight categories, for estimating growth of boys & girls separately. These statistical models enabled us to estimate mean height and weight values of boys and girls against their ages (1 month - 59 months) by different birth-weight categories along with their 95% upper and lower limits. These growth curves are likely to be quite useful in estimating mean values of height and weight for given birth-weights of under-five boys & girls.

Data from four rounds (1992-2016) of the National Family Health Surveys were examined by Anuradha et al (2023). Authors determined the height and weight for age (HAZ, WAZ), and weight for height (WHZ) Z scores. HAZ, WAZ, and WHZ defined malnourished children as those with a Z score of less than - 2[73]. A community-based cross-sectional investigation was carried out by Akhade et al (2019)[71]. Under five-year-old children and their mothers from urban slums were checked and interviewed after they were randomly chosen from 10 slums.

In a growth-Study, using modelling approach[37], Jenss - Bayley Model, Reed model, and Gompertz functions were some of the Structural and Non-Structural Growth Models that have been used to describe child growth. One rationale for fitting models to growth data is that a suitable curve will neatly encapsulate the information offered by an individual child's observations[39]. Not only this, models also generate smooth curves of status as well as of velocity - even from irregularly spaces measurements. By using parametric estimates, one can have more estimates between families of curves. The Jenss-Bayley Model here presented the best fit for weight and height, both for boys and girls[40]. Mean height growth trajectories were identical in shape and direction for boys and girls while the mean weight growth curve of girls fell slightly below the curve of boys after neonatal life.

Similarly, Berkey (1982) compared two statistical models, viz. the *Count Model* - a linear model, and the *Jenss Model* - a non-linear model, for growth in length and weight of the pre-school children in United States. These models were fitted to the large data of length and weight and the results were used to study efficiency, reliability and goodness-of-fit of the models[39]. The author[39] showed that the *Count Model* did not adequately fit to the data while the *Jenss Model* performed well for both - length and weight, of the pre-school children. For assessment of height, weight, and BMI, WHO Growth Standards (for children <5 years) and contemporary Cross Sectional Reference Percentile Curves (for children from 5 to 18 years) are available for clinical use and for research purposes[47]. Further, in growth studies - dealing with height and weight measurements and using Statistical Modelling Approach, modelling weight is often more difficult than height, because weight of children might decrease with age for shorter periods. This however, may not be the case with their height.

Children's growth patterns in India have been influenced by the country's rapid economic and social transformation, particularly in urban regions. According to recent Indian studies[47,49], there is a trend toward increased height, particularly in boys, as well as an increase in obesity in both the genders. Since 2010, the Indian Government have approved the WHO 2006 Growth Guidelines for measuring the growth of children under the age of five years. Khadilkar et al (2015) studied nutritional status of Indian pre-school children taking data from NFHS - 4 and using WHO (2006) and Indian Synthetic Charts (2019). They calculated Z scores of length/heights, weight, and weight-for-height, using both the charts. It was concluded that use of Indian synthetic charts for growth monitoring of under-five children may be more appropriate and that, infants below 6 months and children from well off families performed well[49].

In the present Study, National Family Health Survey - 4 data of the under-five children for the different geographical Region of India have been used. These data were used for estimating child growth curves - considering mean height & weight for boys & girls separately by birth-weight, applying *Cubic Model* and *Power Model* wherever these fitted best. In fact, several factors may play a role in the goodness of fit of any model. Even quality of data also influences model's goodness of fit since several measurement errors increase residuals[38]. As explained above, the National Family Health Survey - 4 data, used in the present study, are from the Government Departments and as such, these are of high quality and, also nationally representative. Thus, in testing goodness of fit of the various models used in our Study, the role of the quality of data might not have played much role.

6. SUMMARY

6.1 Introduction

Malnutrition or growth failure is a worldwide public health problem. It encompasses both –under-nutrition and over-nutrition. Under-nutrition includes wasting (low weight-for-height), stunting (low height-for-age), and under-weight (low weight-for-age) whereas over-nutrition mostly includes overweight & obesity. Malnutrition poses a considerable public health challenge for children below the age of five years - hindering both, their cognitive & physical development while also contributing to child morbidity and mortality. In Underdeveloped as well as Developing Nations, malnutrition continues to pose a severe threat to children's survival, growth, and their development. South East Asian countries including India and Sub-Saharan countries in Africa are specially affected from the malnutrition. In these countries, malnutrition is mostly in form of under-nutrition which is often studied in terms of stunting, wasting and under-weight

Malnutrition significantly influences the global burden of various diseases, with at least 50% of all deaths among children below the age of five years worldwide attributed to under-nutrition each year. In Africa, more than one-third of children under the age of five (39%) are undernourished, and for Sub-Saharan Africa, this figure rises to 41%. Ethiopia, located in Sub-Saharan Africa, stands out as one of the nations with the highest prevalence of under-nutrition. Bangladesh, Pakistan, and India are the three South Asian nations with the highest prevalence of the condition. The *2018 Global Nutrition Report* reveals that one-third of the global population of undernourished children resides in India.

6.2.1 Review of Literature

Stunting: Childhood linear growth faltering, commonly known as stunting, stands as a significant global health concern. In 2017, according to a UNICEF Report[20], the predominant indicator of childhood malnutrition was stunting - impacting an estimated 151 million such children worldwide. The Report highlights a lack of progress toward achieving the 2025 World Health Assembly target of a 40% reduction in stunting. India accounts for approximately one-third of the world's total population of stunted children below the age of years. According to India's National Family Health Survey -3, conducted in 2006, 48% of Indian children, aged 0 to 59 months were stunted. India has made considerable progress in reducing child malnutrition in the last decade however, stunting prevalence remains high and extremely variable across districts and particularly high in populous Northern States.

Wasting: Wasting is one of the symptoms of childhood malnutrition, which can manifest itself in a variety of ways. Malnutrition continues to have an impact on the lives of several young children across the world through wasting. Globally, in the year 2017, nearly 50.5 million children below 5 years of age, representing 7.5% of them, experienced wasting. South East Asia continues to host largest population of wasted children in the world with wasting prevalence over 15%. The occurrence of wasting commonly fluctuates with the changing seasons, influenced by variations in climate, disease patterns, and the availability of food. In India, significant inter-State differences in wasting are often apparent, as evidenced by the period between 2005–2006 and 2019–2021, during which 15 out of 29 Indian States experienced an increase in its prevalence.

Under-Weight: When a child becomes either thin or short for his / her age, he/she is considered to be *underweight*. Even though the percentage of underweight children worldwide has decreased from 25% in 1990 to 15% in 2015, the decline has not been evenly distributed. The prevalence of chronic malnutrition and underweight was around 39.9% and 26.6% throughout Africa and South East Asia respectively in recent past years. The Prevalence of under-weight in under 5 children in rural areas of Rishikesh, Uttarakhand (Rehan et al, 2021)[30] was found to be 37.3%. whereas in a Cross-Sectional Study, carried-out in Maharashtra, it was found to be 35.4%. The prevalence rate of under-weight in India, as per the NFHS - 4, has been 26.6%.

India continues to grapple with a significant public health challenge related to under-nutrition in children below the age of five years.

6.1.2 Justification of the Study

Though the malnutrition is a major health problem in India, yet studies on the growth dynamics of under–5 children, where advanced biostatistical methods have been lacking. Resultantly, nether the better estimates of measurement of under-nutrition, viz.- stunting, wasting, underweight, and overweight, of these children are available nor precise contributions of major risks factors of malnutrition are known. Appropriate and region-specific Growth Nomograms of our children for their different anthropometric measurements are also not available. The present Study is an attempt in these directions., This Study is expected to benefit healthcare planners, and health researchers on children’s growth & development and to the mothers of under-5 children in the country for a better holistic future.

6.1.3 Objectives of the Study

The present Study is aimed to investigate into 3 objectives: firstly, to model growth dynamics of under-five children in terms of stunting, wasting, and underweight in relation to their determinants secondly to study major determinants of the growth of under 5 children and thirdly, to prepare region-specific growth nomogram of above children in different geographical Regions of India.

6.2 Material & Methods

The present work is based on National Family Health Survey-Fourth Round (NFHS-4), conducted in 2015 – 2016. The data of the National Family Health Survey – 5, currently available now, were neither published nor ready to use when the present work was initiated in the year 2020. As such National Family Health Survey-4 (NFHS-4) data have been used to address the objectives of the present study. Further, for the purpose of the present research work, as per NFHS–4, we have divided India into 6 Geographical Regions, such as Central Region, Eastern Region, Northern Region, Northeast Region, Western Region, and Southern Region, specified as under:

i) **Central Region:** Consisting of 3 States – Chhattisgarh, Madhya Pradesh & Uttar Pradesh, this Region included 75,645 children (39,527 boys and 36,118 girls).

ii) **Eastern Region:** Consisting of 4 States - Bihar, Jharkhand, Odisha & West Bengal, this Region included 54,075 children (28,013 boys and 26,062 girls).

iii) **Northern Region:** Consisting of 6 States & 2 UTs: - Chandigarh (UT), Delhi (UT), Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, and Uttarakhand, this region included 48,703 children (25,762 boys and 22,941 girls).

iv) **Northeast Region:** Consisting of 8 States: - Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, this Region included 37,167 children (19,050 boys and 18,117 girls).

v) **Western Region:** Consisting of 3 States & 2 UTs: - Dadra & Nagar Haveli (UT), Daman & Diu (UT), Goa, Gujarat, Maharashtra, this Region included 18,276 children (9,510 boys and 8,766 girls).

vi) **Southern Region:** Consisting of 5 States & 3 UTs: - Andaman & Nicobar Island (UT), Andhra Pradesh, Karnataka, Kerala, Lakshadweep (UT), Puducherry (UT), Tamil Naidu & Telangana, this Region included 25,761 children (13,240 boys and 12,521 girls).

The two statistical Software - SPSS and the MS Excel were used for the analysis of data in the present work. The limited number of variables were extracted from the Kid's File of the SPSS Data to address all the objectives of the Study.

6.3 Results

6.3.1 Status of Under-Nutrition

Amongst 6 Indian regions, stunting had highest prevalence in the Central Region (38.4%) and lowest in the Southern Region (25.9%). Prevalence rate of under-weight ranged between 37.4% (Eastern Region) and 18.4% (Northern Region). Similarly, prevalence of wasting was highest (22.3%) in the Western Region and lowest (11.3%) in the Northeast Region. Further, In all the 6 regions, except the Western Region, component of under-nutrition showing highest prevalence was stunting, followed by under-weight and then, wasting. However, for the Western Region, under-weight showed the highest prevalence rate (32.8%), followed by stunting (31.6%) and then wasting (22.3%).

6.3.2 Growth Dynamics of under 5 Children in terms of Stunting, Wasting & Under-weight in relation to their Major Determinants in Different Indian Regions

The growth dynamics of under 5 children was studied for the two anthropometric measurements – namely, height and weight using *Logistic Regression Model*. Role of major socio-economic &demographic variables in all the 3 components of under-nutrition, viz. – stunting, wasting & under-weight was also studied in the above children for all the 6 Regions separately.

Stunting: In comparison to the richest group in the Central, Eastern, Northern, North-eastern, Western and Southern Regions, odds of stunted children were twice as high as for the poorest group. In addition, in Central, Eastern, and Northern Regions, odds of stunted children were significantly higher for uneducated mothers than for mothers with higher education, Similarly, odds of stunted children were high for birth orders 4 & above as compared to first birth order. Nevertheless, in the Western and North-eastern Regions, odds of stunted children were significantly higher for mothers with only a primary education than for mothers with a higher education. Similarly, in the Southern Region, odds of children with stunting were higher for mothers with a third birth order than for mothers with a first birth order. In the same way, odds of stunted children were significantly higher in underweight women in all six Regions of India than in women, having normal birth-weight.

Wasting: For the poorest group, odds of wasted children were higher as compared to the richest group in Central, Eastern, Northern, Northeast, Western as well as in Southern Region. Odds of wasted children were significantly higher for mothers who were uneducated as compared to the mothers with higher education in Eastern, Northern, Northern, Southern, and Western Region. In Central Region, odds of wasted children were significantly higher for mothers who were uneducated as well as for mothers with primary education compared to the mother with higher education. In Central Region, as compared to the first birth order, odds of wasted children were less in second, third and 4 & above birth orders. But, in Eastern, Northern, and Northeast Regions, odds of wasted children were high in third birth order as compared to first birth order. Similarly, odds of wasted children were considerably high in 4 & above birth order as compared to the first birth order in Southern as well as in Western Region. Furthermore, in all six regions of India, odds of wasted children were significantly higher for underweight women than for women having normal birth-weight.

Under-weight: In the Central, Eastern, Northern, North-eastern, Western, and Southern Regions, chance of underweight children was higher for the poorest group than for the richest group. In comparison to first birth order, odds of underweight children were significantly higher in Central, Eastern, Southern, and Western Regions for birth orders four and above. Similarly, for third birth order, odds of underweight children were significantly high as compared to first birth order in Northeast, and Southern Region. But, odds of underweight children were considerably higher in second and third birth order as compared to the first birth order in Northern Region. Further, compared to normal women, underweight women had significantly higher odds of having underweight children in each of India's six Regions. In comparison to mothers with higher levels of education in the Central, Eastern, North-eastern, Southern, and Western Regions, odds of underweight children were significantly higher for uneducated mothers. Furthermore, in Northern Region, mothers with only primary education had a significantly higher chance of having underweight children than mothers with higher education.

6.3.3 Studying Major Determinants of Growth of Under 5 Children in Different Indian Regions

Generalized Linear Model was applied to estimate height & weights of boys & girls against their ages for all the 6 Regions of the country separately.

Child Height: Socio – demographic variables, viz. – sex, birth order, education, respondent's occupation, wealth index, and BMI were statistically significant with child height in the *Central Region*. However, in the *Eastern Region* and *Northern Region,* variables, viz. – sex, education, wealth index and BMI were significant with the child height. In the *Northeast Region*, variables, viz. – birth order, respondent's occupation, wealth index, BMI, and sex were statistically significant to the child's height, whereas, in the Southern Region, variables, viz.– education, wealth index, and sex were significant with the child height. Similarly, in the *Western Region* variables, viz. – birth order, education, type or residence, wealth index, and sex were significant with the child height.

Child Weight: As regards weight, socio–demographic variables, viz. – sex and age, birth order, education, wealth index, and BMI in Central Region, Eastern Region, Southern Region, and Western Region were significantly associated with the child weight, whereas, sex, age, education level, type of residence, wealth index, and BMI in Northern Region were significant associated with child weight. Similarly, in the Northeast Region, variables, viz. age & sex, education, wealth index, and BMI were found to be statistically significant with child weight.

6.3.4 Growth Nomograms of Height & Weight for Different Birth-Weight Categories in different Indian Regions

For estimating Growth Nomograms - considering height & weight of the Indian children below 5 years of age for the two sexes separately across the Regions, we identified two most suitable statistical models, after critically reviewing 11 statistical models, available on Statistical Software SPSS, As per our Study, for the Central and Eastern Region, socio–demographic variables, viz. – age & sex of a child, birth order and BMI and education status, place of residency, and wealth index were significantly associated with birth weight. In the *Northeast Region*, age, birth order, BMI, education level, type of residence, and wealth index except for sex as well as respondent’s occupation were significantly associated with birth weight. But, for the Northern Region, Southern Region, and Western Region, variables, viz. – age & sex, birth order, BMI, education, respondent’s occupation, type of residency, and wealth index were significantly associated with the birth–weight.

When we considered a particular birth-weight category, Cubic and Power Models proved to be the most appropriate statistical models for assessing child growth in terms of height & weight for both sexes - boys and girls. In Indian Growth Studies, our predicted Growth Charts of average height & weight by age for under 5 boys and girls across all regions of the country, are likely to be helpful for health researchers as well as to the health policy makers in the country.

Our Study concludes that highest prevalence was for stunting, followed by underweight and then wasting for almost all the regions, except the Western Region where the prevalence was highest for underweight, followed by stunting and then wasting. Majority of the socio-economic variables such as wealth index & BMI considered in the Study, were significantly associated with stunting, under-weight and wasting. Similarly, it was in the case with child height and child weight also. Though situation - for under-nutrition as well as for child-growth variables, at times differed for component to component (stunting, wasting & underweight) and also for region to region. Further, growth dynamics – considering height and weight, in terms of stunting, wasting and underweight can easily be studied using *Logistic Regression model*. Similarly, determinants of children's growth was studied using *Generalized Linear Model.* Furthermore, Power *Model* and the *Cubic Model* are most appropriate models for estimating Growth Nomograms of height and weight against ages, considering different birth-weight categories.

7. CONCLUSIONS

The analysis of this research work revealed that, out of 6 geographical Indian Regions studied for under-nutrition, stunting had highest prevalence (38.4%) in Central Region, followed by under-weight (37.4%). in Eastern Region and then wasting (22.3%) in Western Region. As regards, extent of problem of under-nutrition in the different parts of the country, stunting ranged between 25.9% (Southern Region) and 38.4% (Central Region), under-weight ranged between 18.4%.(Northeast Region) and 37.4%.(Eastern Region) and the wasting ranged between 11.3%.(Northeast Region) and 22.3%.(Western Region).

Our analysis further showed that socio–demographic variables, namely - child age and sex, wealth index, mothers' education level, type of residence, birth order, and Body Mass Index (BMI) were significantly associated with stunting in the Central Region, Northeast Region, Northern Region, and Southern Region. In Eastern Region, variables, such as – wealth index, child age, mothers' education level, birth order, and BMI were associated, whereas, in the Western Region, child age and sex, wealth index, mothers' education level, birth order, and BMI were significantly associated with the stunting.

Variables, namely – child age and sex, BMI, type of residence, and wealth index were statistically significantly associated with wasting in the Central Region. In the Northern Region, factors, like – child age and sex, BMI, education status, type of residence, and wealth index were associated, whereas, in the Western Region, variables, viz. – child age and sex, wealth index, and BMI were statistically significant with wasting. Similarly, in Eastern Region, variables, namely – child age and sex, wealth index, type of residence, birth order, and BMI were associated, whereas, in the Northeast as well as Southern Regions, child sex and age, wealth index, mothers' education level, BMI, type of residence, birth order were significantly associated with wasting.

Socio–demographic variables, such as – child sex and age, birth order, BMI, education level, type of residence, and wealth index were statistically significantly associated with underweight in the Central, Northern and Southern Regions. However, in Eastern Region, variables, namely – child age, wealth index, education level, type of residence, birth order, and BMI were associated, whereas, in the Northeast as well as in the Western Regions, child age and sex, wealth index, education level, birth order, and BMI were significantly associated with underweight.

Socio–demographic variables – child sex & age, birth order, education level, wealth index, and BMI were statistically significant in Central, Eastern, Southern, and Western Regions, variables - child sex and age, education level, type of residence, wealth index, and BMI were found to be statistically significant to child weight in Northern Region. Similarly, in the Northeast Region, variables - child age and sex, education level, wealth index, and BMI were statistically significant to the child weight.

In the similar way, socio – demographic variables – child sex, birth order, education level, respondent occupation, wealth index, and BMI were statistically significant to child height in the Central Region. However, in the Eastern & Northern Regions, variables, – child sex, education level, wealth index, and BMI were found be significantly associated with child height. In the Northeast Region, variables – birth order, respondent occupation, wealth index, BMI, and child sex were significantly associated, whereas, in the *Southern Region*, factors – education level, wealth index, and child sex were significant to the child height. Similarly in the Western Region, variables – birth order, education level, type or residence, wealth index, and child sex were found to be significantly associated with the child height.

Our Study further concluded that for the Central & Eastern Regions, socio–demographic variables, namely – age and sex of a child, birth order and BMI and education status, place of residency, and wealth index were significantly associated with birth weight. In the Northeast Region, all above variables, except child sex and respondent's occupation were significantly associated with the birth weight. But, for Northern, Southern, and Western Regions, variables – child age and sex, birth order, BMI, education level, respondent occupation, type of residency, and wealth index were significantly associated to the birth – weight.

Furthermore, taking into account a particular birth-weight category, Cubic and Power Models proved to be the most appropriate statistical model for assessing child growth in terms of height and weight for age, for both the sexes - boys and girls. In Indian growth studies, the predicted Growth Charts of height and weight against age for boys and girls below 5 years of age across all Indian Regions are likely to be quite useful.

7.1 Limitations of the Study

- The present work on growth modeling of under 5 children is not based on the primary data, but on the secondary data which were taken from the National Family Health Survey – Fourth Round. This work may have some limitations which are common to record-based studies or those based on the secondary data.

- While identifying best–fit models to our data for estimating Growth Nomograms, we considered only well-known 11 statistical models which are available in the Statistical Software SPSS.
- The Growth Nomograms for under 5 children, in the present work, have been studied for broad Indian Regions and not for the country as a whole or by States. In growth studies of such children, one may need National Growth References or State Growth References for purpose of comparison.
- This Study has used a few predictor variables, namely – child age and sex, birth order, Body Mass Index (BMI), mother's education level, respondent's occupation, type of residence, and wealth index to investigate into their role as growth-determinants. There could be some more such factors, playing significant role in the growth of these children. It would have been better to include a few more prominent & relevant such factors.

7.2 Merits of the Study & Recommendations

- Malnutrition is presently a problem of world's several Developing & Under Developed Countries, including India. The present research work thus, is on a very important public health problem.
- This study used country's NFHS-4 data. As data in NFHS are collected by a trained Government machinery, following all requisite norms, its quality & recognition is well established. Thus, our study's results – based on NFHS 4 data should be highly reliable.

- Our Regional Growth Nomograms can be used as Regional References in growth studies. Such References are quite important in growth studies but are often not available to the researchers.
- Our study provides region-wise useful results on under-nutrition, particularly on stunting, wasting, and underweight for under 5 children of the country. Such results are likely to be quite useful to those public health workers who are working to control malnutrition in the country.
- In our study, region – wise results are shown. But State wise, district – wise and economic status-wise results are not shown. It is thus, recommended that such results may be shown by future studies to be taken-up by others.
- Only a set of predictor-variables, namely – child age & Sex, birth order, Body Mass Index (BMI), mother's education level, respondent's occupation, type of residence, wealth index, have been covered in the study to investigate their role in the child growth and evaluate them as its determinants. Effect of few more such predictor variables (such as -age at marriage, religion, breast-feeding, type of toilet facility, etc) on growth & its related aspects also needs to be studied. It is recommended that such important predictor-variables, should be taken up by the future researchers of the area for establishing their contributions in the under-nutrition and growth of the under 5 children.

7.3 Health Policy Implications

- This Study found, varying factors affecting under 5 children's growth. These include series of socio-economic & demographic variables. Several such variables have been found to be statistically significant, as regards their association with stunting, wasting, and underweight, for 6 broad geographical

Indian Regions. Hence, policy planner and makers have to take care of such factors while framing policy & programs for the Regions to reduce malnutrition amongst under 5 children.

- Some of the correlates, such as - Body Mass Index (BMI), mother's highest level of education, place of residence and wealth index etc, were found to be significantly associated with the birth-weight of the under 5 children. Thus, while chalking-out Government programs to enhancing the birth-weight in the regions, adequate focus should be given on these factors.
- Child growth varied by regions. Hence, to monitor growth of under 5 children in a Region, Region – Specific – Growth - Charts should be pursued. Further, country's Regional Health Agencies, Union & State Health Ministries – particularly, NITI Aayog, ICMR and Private Sector Health Organizations, may find our Study's results quite beneficial while planning & implementing their health programs & policies on growth of children below five years of age in the country.

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ANNEXURES

A. CERTIFICATE

EFICON 2022

3RD ANNUAL NATIONAL CONFERENCE OF EPIDEMIOLOGY FOUNDATION OF INDIA
ALL INDIA INSTITUTE OF MEDICAL SCIENCES, PATNA

Certificate of Participation

This is to certify that Dr. /Mr./ Ms. Pradyuman Verma

has participated as a delegate in the 3rd Annual National Conference of Epidemiology Foundation of India- EFICON 2022, held on 4th – 5th November 2022 organized by Community and Family Medicine Department of All India Institute of Medical Sciences Patna.

This certificate has been awarded 8 Credit Points by The Bihar Council of Medical Registration.

Dr. Sahajanand pd. Singh
Registrar, BCMR

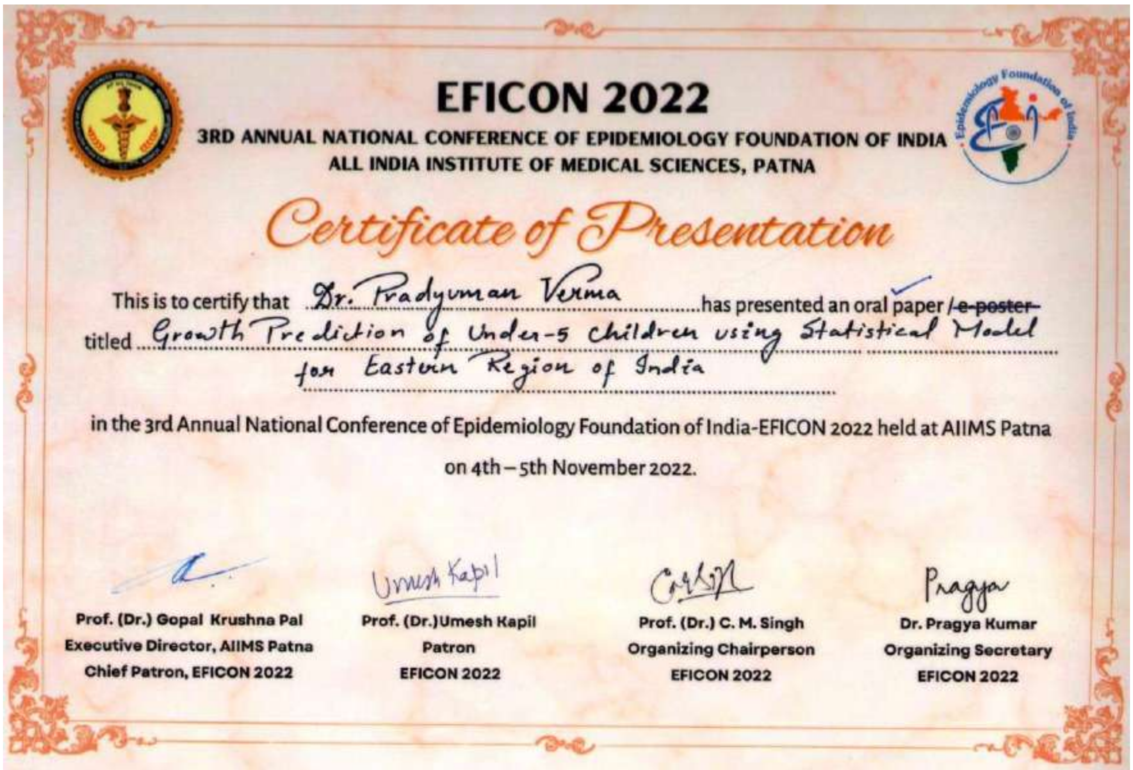
Dr. Sunil Kumar Singh
Co-chairman, Academic, BCMR

Dr. Basant Singh
Chairman, Academic, BCMR

Prof. (Dr.) Gopal Krushna Pal
Chief patron, ED, AIIMS Patna

Prof. (Dr.) C. M. Singh
Organizing Chairperson

Dr. Pragya Kumar
Organizing Secretary



EFICON 2022

3RD ANNUAL NATIONAL CONFERENCE OF EPIDEMIOLOGY FOUNDATION OF INDIA
ALL INDIA INSTITUTE OF MEDICAL SCIENCES, PATNA

Certificate of Presentation

This is to certify that Dr. Pradyuman Verma has presented an oral paper / ~~e-poster~~ titled Growth Prediction of Under-5 Children using Statistical Model for Eastern Region of India

in the 3rd Annual National Conference of Epidemiology Foundation of India-EFICON 2022 held at AIIMS Patna on 4th – 5th November 2022.

Prof. (Dr.) Gopal Krushna Pal
Executive Director, AIIMS Patna
Chief Patron, EFICON 2022

Prof. (Dr.) Umesh Kapil
Patron
EFICON 2022

Prof. (Dr.) C. M. Singh
Organizing Chairperson
EFICON 2022

Dr. Pragya Kumar
Organizing Secretary
EFICON 2022

40th Annual National Conference of the Indian Society for Medical Statistics

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ISMSCON 2022

24-26 November, 2022

Organized by Department of Community Medicine, Krishna Institute of Medical Sciences, Karad

Certificate of Recognition

This is to Certify that

~~Dr.~~/Mr./~~Mrs./Miss~~ Pradyuman Verma

has presented a paper entitled Growth Estimation of Under - Five Children Using Statistical Models in Central Region of India

in Oral/~~Poster~~ session in the '40th Annual National Conference of the Indian Society for Medical Statistics' organized by Krishna Institute of Medical Sciences, Karad during 24th – 26th November, 2022.

Dr. Mohite R. V. Chairperson Scientific Session ISMSCON 2022	Dr. Kakade S. V. Organizing Secretary ISMSCON 2022 KIMS, Karad	Dr. Durgawale P. M. Organizing Chairperson ISMSCON 2022 KIMS, Karad	Dr. L. Jeyaseelan President, Indian Society for Medical Statistics	Dr. S. T. Mohite Dean, KIMS, Karad

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Dr. Kakade S. V. Organizing Secretary ISMSCON 2022 KIMS, Karad	Dr. Durgawale P. M. Organizing Chairperson ISMSCON 2022 KIMS, Karad	Dr. L. Jeyaseelan President, Indian Society for Medical Statistics	Dr. S. T. Mohite Dean, KIMS, Karad

B. PUBLICATIONS

Original Article

Growth Prediction of Under-5 Children Using Statistical Models for Eastern Region of India

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Abstract

Background: Percentile curves are often used to assess variances in children's growth pattern. This study is aimed at explaining effect of the respondents' sociodemographic characteristics on under-5 children's birth weight and identifying most suitable models, out of 11 statistical models reviewed, for estimating children's growth in terms of height and weight of a given birth-weight category and obtain estimated growth curves. **Material and Methods:** The study used National Family Health Survey (NFHS)-4 data from four Eastern States of India, consisting of 54,075 under-5 children. Estimated growth curves were obtained, using best-fit models. **Results:** Birth weight was found to be associated with children's age, gender, birth order, body mass index, mother's education, living place and wealth index. Two models – *Cubic Model and Power Model* – showed best fit to the height and weight measurements. We obtained estimated growth curves of boys and girls for a given birth-weight category. **Conclusions:** All socio-demographic factors studied, except respondent's occupation, were associated with children's birth weight. *Cubic and Power Models* were most suitable for assessing growth in terms of height and weight of boys and girls, belonging to a given birth-weight category.

Keywords: Anthropometry, birth weight, child growth, statistical models, under-5 children

Introduction

Childhood, characterized by growth, is basically a physiological process.[1] Growth trajectories provide essential indicators for child development and act as potential determinants of adult health outcomes.[2] Growth charts are frequently used as an important tool for measuring children's growth and their nutritional status.[3] Several countries have created their own growth references, taking into account racial and ethnic varieties and environmental variables in human growth across the world.[3] In general pediatric practice, measurements, such as length/height and weight are widely acknowledged in child growth and development. Their comparison to national or international growth references is often done to determine variations in their growth patterns.[4] WHO Growth References for children, aged 0–5 years, as well as for children and adolescents, aged 5–19 years, were brought-forth sometime back and have been in use since then.[5,6]

In order to study child growth and growth trajectories, mathematical modelling is a powerful tool. It entails fitting models to physical growth data in order to obtain appropriate growth curves provided by children's anthropometric measurements, such as height and weight, even if these are irregularly spaced.[7] Further, nearly 30% of preschool children in impoverished nations have stunted growth as a result of local environmental factors.[8] Indonesian children continue to be among the world's smallest and that stunting is present in them up to 43% of Indonesian districts.[9] Further, as India is going through a nutritional shift, it is critical to keep its growth figures up-to-date.[10] Children's growth patterns in India have been influenced by the country's rapid economic and social transformations. According to a recent Indian study, there is a trend toward increased height, particularly in boys and obesity in both genders.[11] In 2010, Indian Government had approved WHO 2006 Growth Guidelines for measuring growth of children below 5 years of age.[11] In 2019, synthetic

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growth references for Indian children, aged 0–18 years were also released.[12] The present study is aimed at explaining the effect of the respondents' sociodemographic characteristics on their under-5 children's birth weight and identifying most suitable models, out of 11 statistical models reviewed, for estimating growth of children and also, to obtain their estimated growth curves in terms of average height and weight, given their birth-weight categories.

Material and Methods

The study used data of the India's National Family Health Survey (NFHS)-4. The NFHS-4, a comprehensive survey, collected data on children aged 0–59 months with a variety of demographic and socioeconomic factors and different anthropometric measurements. A total of 2,59,627 children were studied in this survey, and out of these, 54,075 children (28,013 boys and 26,062 girls) belonged to the four states – Bihar, Jharkhand, Odisha, West Bengal. These four states are also called country's Eastern Region. In the present study, we used height and weight data to estimate children's growth. Children were first categorized into four subgroups by their birth weight:(*a*) <2000 gm, (*b*) 2000–2499 gm, (*c*) 2500–2999 gm, and (*d*) 3000 gm+, and then their height and weight curves were obtained, using best-fit models, out of 11 statistical models reviewed.[13]

Statistical models applied for estimated growth curves and criteria for best-fit models

We carried out statistical analysis, using IBM SPSS 20 Software and Excel. SPSS 20 Software contained only 11 statistical models, and all these models were fitted to the NFHS-4 data on height and weight for boys and girls, considering four birth-weight categories. These 11 statistical models have also been employed for growth estimation of under-5 children of India's Central Region.[13] A model with highest coefficient of determination (R^2) was chosen to be the best-fit model. The 11 statistical models, used in the study, are given below.

$(a)\ Linear\ Model: E(Y_t) = \alpha_0 + \alpha_1 t$

$(b)\ Logarithmic\ Model: E(Y_t) = \alpha_0 + \alpha_1 \ln(t)$

$(c)\ Inverse\ Model: E(t) = \alpha_0 + \alpha_1 / t$

$(d)\ Quadratic\ Model: E(Y_t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2$

$(e)\ Cubic\ Model: E(Y_t) = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3 t^3$

$(f)\ Compound\ Model: E(Y_t) = \alpha_0 \alpha_1^t$

$(g)\ Power\ Model: E(Y_t) = \alpha_0 t^{\alpha_1}$

$(h)\ S\ Model: E(Y_t) = \exp(\alpha_0 + \alpha_1 / t)$

$(i)\ Growth\ Model: E(Y_t) = \exp(\alpha_0 + \alpha_1 t)$

$(j)\ Exponential\ Model: E(Y_t) = \alpha_0 e^{\alpha_1 t}$

$(k)\ Logistic\ Model: E(Y_t) = \left(\frac{1}{u} + \alpha_0 \alpha_1^t\right)^{-1}$

Here, $\alpha_0, \alpha_1, \alpha_2$, and α_3 are coefficients and Y_t = observed values, for $t = 1,2,3,\ldots,n$ and $E(Y_t)$ = Expeceted values of Y_t.

Our analysis revealed that only two statistical models: (e) *Cubic Model* and (g) *Power Model* best fitted to the height and weight data, considering above 4 birth-weight categories for estimating growth of boys and girls under the age of 5 years.

As explained above, children's birth weight was classified into four categories, namely: (*a*) <2000 gm, (*b*) 2000–2499 gm, (*c*) 2500–2999 gm, and (*d*) 3000 gm+. For purpose of data analysis, we used appropriate filters at different birth-weight categories.

For the weight of boys:

a. At birth weight < 2000 gm,

   Filter: child's age>0 and birth weight=<2000 gm and sex of child=male

b. At birth weight 2000–2499 gm,

   Filter: child's age>0 and birth weight=2000–2499gm and sex of child=male

c. At birth weight 2500–2999 gm,

   Filter: child's age>0 and birth weight=2500-2999gm and sex of child=male

d. At birth weight 3000 gm +

   Filter: child's age >0 and birth weight = 3000 gm + *and sex of child = male and child weight <40,000* gm

Here, a filter was applied in all four birth-weight groups, that is, in group (a)–(d). However, in group (d) at birth weight 3000 gm +, *child weight* <40,000 gm was added in the filter because extreme values of more than 40,000 gm were to be excluded.

Similarly, for weight of girls,

a. At birth weight <2000 gm,

   Filter: child" s age>0 and birth weight=<2000 gm and sex of child=female

b. At birth weight 2000–2499 gm,

   Filter: child's age>0 and birth weight=2000-2499 gm and sex of child=female

c. At birth weight 2500-2999 gm,

   Filter: child' s age>0 and birth weight=2500-2999 gm and sex of child=female

d. At birth weight 3000 gm +

Filter: child's age >0 and birth weight = 3000 gm + *and sex of child = female and child weight <40,000* gm

Here also, a filter was applied in all four birth-weight groups, that is, in group (a)–(d). However in group (d) at birth weight 3000 gm + *child weight* <40,000 gm, was added in the filter because extreme values of more than 40,000 gm were to be excluded.

Results

Under-5 children's birth weight and sociodemographic characteristics

Table 1 gives distribution of under-5 children by their birth weight and eight sociodemographic characteristics, namely, child age, sex, birth order, body mass index (BMI), respondent's highest educational qualification, respondents' occupation, place of residence, and wealth index. Our analysis showed that birth weight was significantly associated with seven out of eight sociodemographic variables. Thus, birth weight had association with age of child (χ^2 = 138.02, *d.f.* = 12, P<0.001),sex of child (χ^2 = 97.15,*d.f.*= 3, P<0.001) and birth order (χ^2 = 1403.64, *d.f.*= 9, P<0.001). BMI was also found to be significantly associated (χ^2=87.72, *d.f.* = 9, P<0.001) with birth weight. When mothers' highest education level and children's birth weight were taken into consideration, our analysis again revealed a strong association between the two factors (χ^2 = 1276.73, *d.f.* = 9, P<0.001).. Analysis demonstrated that respondents' two factors – place of residence and wealth index – also play a role in the determination of children's birth weight. This is because respondents' place of residence (χ^2 = 212.09, *d.f.* = 3, P<0.01) as well as their wealth index (χ^2=715.77, *d.f.* = 12, P<0.001) too exhibited strong association with children's birth weight. Only one factor that did not show any association with children's birth weight was respondents' occupation (χ^2 = 11.53, *d.f.* = 9, P=0.241).

Growth prediction of under-5 children using statistical models

As indicated in the Methods Section, only two models *Cubic Model and Power Model* showed best fit to the height and weight measurements. Thus, for purpose of growth prediction using height and weight curves, results of only two best-fit models have been shown here [Tables 2 and 3].

Table 2 describes model's summary for estimating height of boys and girls separately by birth weight. Here, for height of boys, *Power Model* showed best fit for the birth-weight group <2000 gm (R^2 = 0.794) but for the rest of the three birth-weight groups, *Cubic Model* was the best-fit model. Thus, *Cubic Model* showed best fit (R^2=0.805) for birth-weight group 2500–2999 gm, followed by 2000-2499 gm (R^2=0.787) and then 3000 gm and above (R^2=0.776). Similarly, for height of girls, *Power Model* again showed best fit for the birth-weight group <2000 gm (R^2 = 0.820) but for the rest of three birth-weight groups, *Cubic Model* was the best-fit model. Thus, *Cubic Model* showed best fit for birth-weight group 2000-2499 gm (R^2 = 0.795), followed by 2500 -2999 gm (R^2 = 0.788) and then 3000 gm and above (R^2=0.757).

Table 3 describes model's summary for estimating weight of boys and girls separately by birth weights. For the weight of boys as well as girls, best-fit model was the *Power Model*. Further, considering boys, this model fitted best for birth-weight group 2500-2999 gm (R^2 = 0.768), followed by 2000-2499 gm (R^2 = 0.750), <2000 gm (R^2 = 0.746), and then 3000 gm and above (R^2=0.733). For estimating weight of girls, *Power Model* showed best-fit for birth-weight group <2000 gm (R^2=0.785), followed by 2500-2999 gm (R^2 = 0.764), 2000-2499 gm (R^2 = 0.762), and then 3000 gm and above (R^2 = 0.726).

Estimated mean height and weight curves and their 95% upper and lower bounds

We calculated growth values for boys and girls separately, based on mean height as well as weight of under-5 children for age ranging from 1 to 59 months, taking into account all four birth-weight categories and using either *Cubic* or *Power Models* – wherever these fitted best. Resultantly, mean height and weight curves were produced separately for two sexes, considering all four birth-weight groups. Figures 1(a)–(d) presents estimated mean height and weight curves of boys for all four birth-weight groups. Similarly, such estimated mean height and weight curves for girls for all four birth-weight groups are shown in Figures 2(a)–(d). The graphs shown, besides giving estimated mean height and mean weight curves also give curves for 95% upper as well as lower bounds. Thus, using curves of Figures 1(a)–(d) and Figure 2(a)–(d), it is possible to derive not only the expected average growth values of under-5 children in terms of their mean height and mean weight for their ages but also their 95% upper and lower bounds in each case.

Discussion

As our country is going through a nutritional transition, it is critical to keep track on growth of children on regular basis. Growth is not only considered as an indicator of health but also its secular trend demonstrates level of the population health. In growth studies, we often make use of growth standards and growth references. Growth standards define how a child population should grow, given optimal nutrition as well as optimal health, whereas growth references are descriptive in nature and are prepared from a population which is thought to be growing and keeping best possible nutrition and health.[10] As children's growth patterns alter over time, their growth references should also be revised from time to time.

Children's birth weight is regarded as an important parameter of their health. Protein energy malnutrition has been found to be its predictor.[14] For the assessment of new-borns' survival and development, birth weight is frequently regarded as a single important factor. For India, we analyzed NFHS-4 data of under-5 children from four states – Bihar, Jharkhand, Odisha, and West Bengal, to investigate the association between children's selected sociodemographic variables and birth weights. Our analysis demonstrated a significant association of birth weight

Table 1: Under-5 children of different birth-weight categories by their sociodemographic characteristic in Eastern Region of India

Sociodemographic Characteristics	Birth weight (gm)								
	< 2000		2000-2499		2500-2999		3000+		Total
	n_1	%	n_2	%	n_3	%	n_3	%	n
Child Age (Months)									
<12	284	2.6	1020	9.5	3010	27.9	6472	60	10,786
12-23	295	3.1	938	9.8	2617	27.3	5728	59.8	9578
24-35	249	2.5	930	9.3	2748	27.4	6087	60.8	10,014
36-47	242	2.3	884	8.4	2660	25.3	6716	63.9	10,502
48-59	260	2.6	754	7.5	2410	24.1	6585	65.8	10,009
$\chi^2(d.f.=12)=138.020, p<0.001$									
Sex of Child									
Boy	713	2.5	2316	8.3	6923	24.7	18061	64.5	28,013
Girl	824	3.2	2482	9.5	6974	26.8	15782	60.6	26,062
$\chi^2(d.f.=3)=97.151, p<0.001$									
Birth Order									
1	777	4.1	2059	11	5807	30.9	10126	54	18,769
2	389	2.5	1348	8.5	4275	27.1	9765	61.9	15,777
3	192	2	710	7.5	2102	22.3	6425	68.1	9429
4 & above	179	1.8	681	6.7	1713	17	7527	74.5	10,100
$\chi^2(d.f.=9)=1403.64, p<0.001$									
BMI (kg/m²)									
<18.5	562	3.4	1677	10	4393	26.3	10,080	60.3	16,712
18.5-24.9	825	2.6	2722	8.4	8204	25.4	20,550	63.6	32,301
25.0-29.9	105	2.9	307	8.3	964	26.2	2304	62.6	3680
≥30	28	3.5	53	6.7	205	26	503	63.8	789
$\chi^2(d.f.=9)=87.723, p<0.001$									
Respondent's Highest Educational Level									
No Education	516	2.2	1768	7.5	4646	19.7	16694	70.7	23624
Primary	233	3.1	715	9.5	2013	26.8	4542	60.5	7503
Secondary	692	3.4	2080	10.3	6413	31.6	11085	54.7	20,270
Higher	96	3.6	235	8.8	825	30.8	1522	56.8	2678
$\chi^2(d.f.=9)=1276.732, p<0.001$									
Respondent's Occupation									
No Occupation	207	3	625	9	1855	26.6	4291	61.5	6978
Others	28	3.2	89	10.1	229	26.1	531	60.5	877
Agriculture	17	1.9	80	8.8	214	23.6	595	65.7	906
Don't Know	2	2	8	7.9	23	22.8	68	67.3	101
$\chi^2(d.f.=9)=11.531, p<0.241$									
Place of Residence									
Urban	272	3.5	771	9.8	2462	31.3	4349	55.4	7854
Rural	1265	2.7	4027	8.7	11,435	24.7	29,494	63.8	46,221
$\chi^2(d.f.=3)=212.092, p<0.001$									
Wealth Index									
Poorest	648	2.4	2162	8.1	5746	21.6	18,085	67.9	26,641
Poorer	427	3.2	1309	9.7	3739	27.8	7982	59.3	13,457
Middle	236	3.1	703	9.3	2362	31.3	4256	56.3	7557

Contd...

Table 1: Contd...

Sociodemographic Characteristics	Birth weight (gm)								
	< 2000		2000-2499		2500-2999		3000+		Total
	n_1	%	n_2	%	n_3	%	n_3	%	n
Richer	155	3.5	463	10.4	1417	31.8	2421	54.3	4456
Richest	71	3.6	161	8.2	633	32.2	1099	56	1964
	$\chi^2(d.f.=12)=715.770, p<0.001$								

Table 2: Model's summary for height of boys and girls by their birth-weight categories: NFHS-4 (2015-16)

Birth weight (gm)	Model	R^2	Constant	d.f.*		F	b_1	b_2	b_3
				Regression	Residuals				
Boys									
<2000	Power	0.794	45.357	1	580	2236.670	0.186	-	-
2000-2499	Cubic	0.787	53.988	3	2110	2600.162	1.766	-0.33	0.0002
2500-2999	Cubic	0.805	54.833	3	6505	8934.308	1.701	-0.029	0.0002
3000+	Cubic	0.776	56.535	3	16,343	18,908.822	1.586	-0.027	0.0002
Girls									
<2000	Power	0.820	44.030	1	707	3228.263	0.190	-	-
2000-2499	Cubic	0.795	53.413	3	2265	2936.483	1.666	-0.029	0.0002
2500-2999	Cubic	0.788	54.647	3	6557	8146.196	1.588	-0.025	0.0001
3000+	Cubic	0.757	55.537	3	14,329	14,846.329	1.530	-0.025	0.0001

Note: *d.f.: – degree of freedom

Table 3: Model's summary for weight of boys and girls by birth-weight categories: NFHS-4 (2015-16)

Birth weight (gm)	Model	R^2	Constant	*d.f.		F	b_1
				Regression	Residuals		
Boys							
<2000	Power	0.746	2742.468	1	581	1709.032	0.393
2000-2499	Power	0.750	3276.688	1	2115	6337.666	0.345
2500-2999	Power	0.768	3430.093	1	6515	21,606.757	0.339
3000+	Power	0.733	3747.194	1	16356	44,832.622	0.316
Girls							
<2000	Power	0.785	2546.490	1	707	2573.891	0.396
2000-2499	Power	0.762	3066.895	1	2268	7255.047	0.350
2500-2999	Power	0.764	3277.480	1	6566	21,286.691	0.338
3000+	Power	0.726	3391.454	1	14335	38,065.486	0.329

Note: *d.f.: – degree of freedom

with age and sex of the children, their birth order, BMI, mother's highest level of education, place of residence, and wealth index. In a cross-sectional study by *Borah and Agrawala*[15] carried out in a rural block of the Assam State (India), illiterate teenage mothers, grand multipara mothers with short interpregnancy intervals, and anemic mothers found to be risk factors of the low birth weight. Another study by *Mishra et al.*[16] demonstrated that underweight rural women and those with no or primary education, low BMI, households with unclean cooking fuel, and women from Northern and Eastern regions of the country had higher share of low birth weight.

Statistical modelling approach in growth studies is a strong tool for analyzing children's growth and trajectories. It allows one to create appropriate growth curves by fitting models to physical growth data. Our results demonstrated that, out of 11 models applied, only two models – *Cubic Model and Power Model* – showed best fit, considering measurements of height and weight of under-5 children. These models allowed us to obtain mean height and weight of boys and girls as a function of age for different birth-weight categories, as well as their 95% upper and lower bounds. The estimated growth curves are likely to be quite useful in predicting average height and weight of under-5 children by age for a given birth-weight category.

One rationale which is often given for using modelling approach to growth data is that a suitable curve will neatly encapsulate the information offered by an individual child's

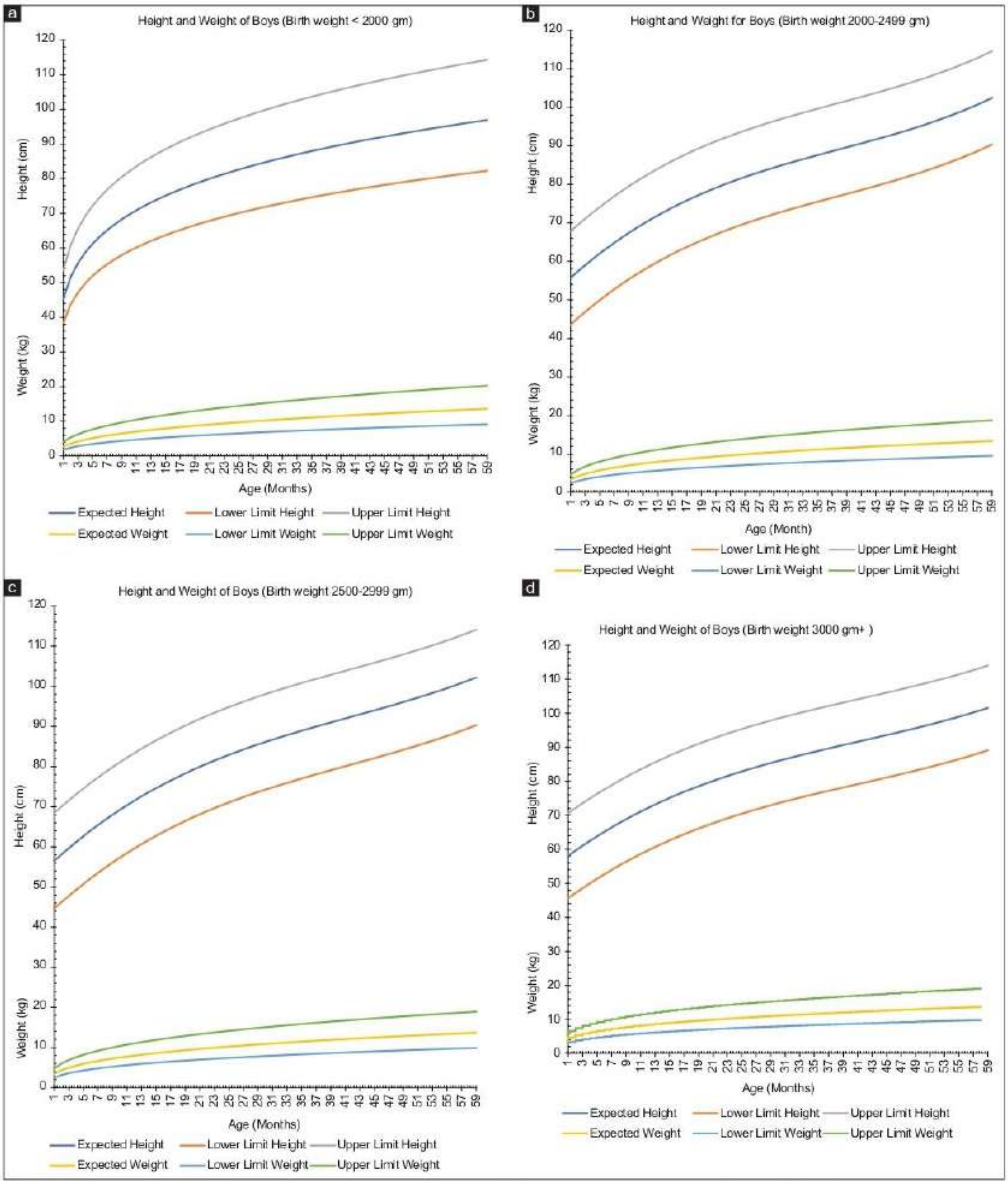

Figure 1: (a) Estimated mean height &and weight curves of boys,using the Power Model in Eastern Region (India): NFHS--4 (Birth -weight<2000 gm). (b) Estimated mean height and weight curves of boys using the Cubic and Power Models respectively in Eastern Region (India): NFHS-4 (Birth weight 2000–2499 gm). (c) Estimated mean height and weight curves of boys, using the Cubic and Power Models, respectively, in Eastern Region (India): NFHS-4 (Birth weight 2500–2999 gm). (d) Estimated mean height and weight curves of boys, using Cubic and Power Models, respectively, in Eastern Region (India): NFHS-4 (Birth weight 3000 gm+)

observations. In addition, statistical models also generate smooth curves of status as well as of velocity – even from irregularly spaced measurements. Furthermore, by using parametric estimates, one can have more estimates

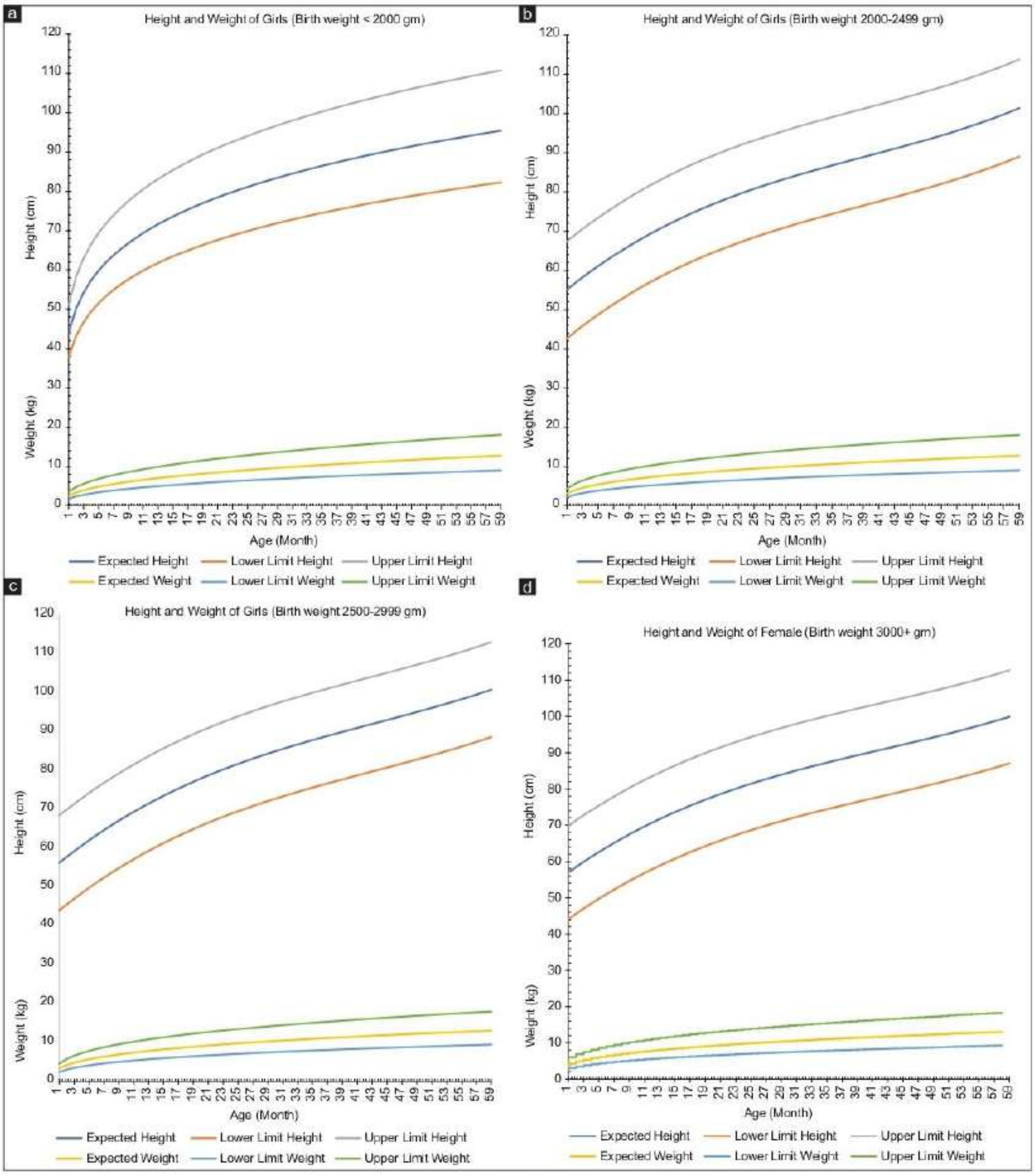

Figure 2: (a) Estimated mean height and weight curves of girls, using Power Model in Eastern Region (India): NFHS-4 (Birth weight <2000 gm). (b) Estimated mean height and weight curves of girls, using Cubic and Power Models respectively in Eastern Region (India): NFHS-4 (Birth weight 2000–2499 gm). (c) Estimated mean height and weight curves for girls, using the Cubic and Power Models, respectively: NFHS-4 (Birth weight 2500–2999 gm).(d) Estimated mean height and weight curves of girls, using the Cubic and Power Models, respectively, in Eastern Region (India): NFHS-4 (Birth weight 3000 gm +)

for families of curves. The Jenss–Bayley Model have demonstrated best fit for height and weight, both for boys and girls.[7] The authors also found that mean height growth trajectories were identical in shape and direction for boys as well as for girls, while the mean weight growth curve of girls fell slightly below the curve of boys after their neonatal life.[7] Berkey[17] in 1982 compared two statistical models, namely, Count Model – a linear model, and the Jenss Model – a nonlinear model, for growth in terms of length and weight of the preschool children in United States. Author fitted these models to a large amount of data on length and weight and results were used to study efficiency, reliability, and goodness-of-fit of the models. The author showed that the Count Model did not adequately fit to the data, while the Jenss Model fitted to the data very well for both length and weight of the pre-school children.

Country's rapid economic and social transition had an impact on children's growth patterns in India.[10] According to some Indian studies,[11,12] there is a trend toward increasing height, especially among boys, as well as an increase in obesity among both sexes. In the present study, we used NFHS-4 data for the Eastern Region of India. These data have been utilized for estimating growth curves of under-5 children, considering mean height and weight for boys and girls separately for different birth-weight categories, applying *Cubic Model and Power Model*. In fact, several factors may play a role, including the quality of data used, in the goodness of fit of any model. As explained above, NFHS-4 data used in this study belong to the Government Department, and so, these should be of high quality.

Conclusions

Sociodemographic factors – age and sex of child, birth order and BMI, and mother's highest level of education, their place of residence, and wealth index – were significantly associated with the birth weight of the under-5 children. Two statistical models – *Cubic Model and Power Model* – were found to be most suitable for estimating child growth curves in terms of mean height and weight of boys and girls – considering their specific birth-weight category. Estimated growth charts of mean height and weight of under-5 boys and girls are likely to be quite useful in the context of Indian growth studies, particularly from its Eastern Region.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Growth Estimation of Under-Five Children Using Statistical Models in Central Region of India

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ABSTRACT

Background and aims: To determine the suitability of 11 basic statistical models for estimating child-growth of under-five children and to bring-forth estimated growth curves for mean height & mean weight by their selected birth-weight categories for Central Region of India.

Methods: The study used fourth round of National Family Health Survey-4 (NFHS-4) data of India, consisting of 75,645 under-five children, belonging to 3 Indian States – Chhattisgarh, Madhya Pradesh & Uttar Pradesh. The children of the Region were first divided into 4 sub categories according to their birth-weight: (i) < 2000 gm, (ii) 2000–2499 gm, (iii) 2500–2999 gm (iv) 3000+gm, growth curve for mean height and mean weight were estimated for two sexes.

Results: The significant association of 7 socio-demographic factors studied, namely – age & sex of child, birth-order, BMI, mother's highest level of education, place of residence and wealth index. Further, Cubic Model and Power Model, demonstrated best-fit to height & weight data of under-five children, belonging to different birth-weight categories, for estimating growth of boys & girls separately. These models enabled us to estimate mean height and mean weight, with 95% CI, for boys and girls separately by different birth-weight categories.

Conclusions: Study concluded that 7 socio-demographic factors were significantly associated with birth-weight. Further, Cubic Model and Power Model were most suitable for estimating child growth in terms of mean height & mean weight for boys and girls – considering specific birth-weight categories.

1. Introduction

Growth is a complex biological process whereby an organism achieves increase in mass and size. Also, it matures morphologically and functionally until it acquires characteristics of the adult state. Growth is fundamentally a physiological process that characterizes childhood [1]. The Paediatric Practice - measuring length and height, is generally an important and commonly acknowledged aspect for monitoring child's growth and development [2]. To analyse variations in the growth pattern and abnormal growth, a comparison is often made with reference populations. The World Health Organization (WHO) have published in 2006–2007, *Guidelines* for assessing growth and development of children under the age of five years, as well as a growth references for school-aged children and adolescents, based on a Multicentre Growth Reference Study (MGRS) [2]. An article has also compared national height references to WHO growth standards - using data from the United Arab Emirates, Peru, Vietnam, Hong Kong, United Kingdom, and Norway [2].

Nearly 30% of pre-school children in Developing Countries have stunted growth as a result of local environmental factors, mostly poor nutrition and illnesses [3]. Because of the rapid rate of growth and sensitivity to external factors in that age range, growth - especially during infancy, is considered to be significant. Because children's growth patterns change over time, it is essential that growth-references are updated on regular basis. As India is presently moving through a nutritional shift and therefore, it's critical to keep-up with the latest growth figures [4]. In India, previously available growth reference curves were mostly based on data, gathered by Agrawal et al. in 1989 which were published in 1992 & 1994, and then adopted in 2007 by the *Indian Academy of Paediatrics* for growth monitoring [2]. In 2006, the World Health Organization issued revised growth standards for children below the age

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1871-4021/

of five years [2]. These have been adopted by several nations, including India as the global unified standards of childhood growth for children below 5 years of age [2].

Children's growth patterns in India have been influenced by the country's rapid economic and social transformations, particularly in urban regions. According to a recent Indian study [5], there is a trend in the country towards increase in height. In the year 2010, Indian Government had approved WHO 2006 Growth Guidelines for measuring the growth of children under the age of five years [5]. In 2019, *Synthetic Growth References* for Indian children, aged 0–18 years were also provided [6]. Further, for studying child growth, mathematical growth modelling is sometimes, considered to be the useful tool. It entails fitting models to physical growth data in order to obtain appropriate growth curves that conveniently summarises important growth information, provided by children's weight and height measurements, etc.

The objective of the present study is to determine the suitability of the applied statistical models for estimating the child-growth in terms of height & weight of under-five children and to bring-forth estimated growth curves for mean height & mean weight by the selected birth-weight categories for Central Region of India.

Growth charts - based on anthropometric measurements of under – 5 children, are of great significance for medical – particularly child care specialists. By clinicians, such charts are used as an important tool for monitoring physical health & wellness of children. Sometimes, growth charts are used to evaluate if a child is receiving proper nutrition or otherwise. Clinicians, at times, have used growth charts in under – 5 children to screen-out their inadequate growth that could be because of adverse health conditions. In the beginning, main concern of applying growth curves was mainly for under-nutrition. However in recent decades, as excessive weight-gain in children below 5 years of age have gradually increased, focus of using these charts have slowly started shifting to screen–out children for over–weight and obesity also.

2. Material and methods

The data of the fourth round of National Family Health Survey - 4 (NFHS-4) of India were used for the present study. The National Family Health Survey – 4, a large & thorough Survey of the country, included data of children, aged 0–59 months along-with their various demographic & socioeconomic characteristics and anthropometric measurements, such as: birth-weight, their current weight and height/length. This Survey resulted in anthropometric data of 2,59,627 children under the age of five years. Out of this, a total of 75,645 children (39,527 boys and 36,118 girls) belonged to the Central Region of India. It may be pointed-out here that the Central Region of India consisted of 3 States, namely – Chhattisgarh, Madhya Pradesh & Uttar Pradesh.

In the present study, we utilized data for estimating child growth – using data on weight and height for boys and girls separately for the Central Region. The children of the Region were first divided into 4 sub categories according to their birth-weight: (*i*) $<2000\,gm$, (*ii*) $2000-2499\,gm$, (*iii*) $2500-2999\,gm$ & (*iv*) $3000+gm$ and then, growth curves for mean height and mean weight were estimated of the under-5 children for the two sexes, using 11 basic statistical models given below for the purpose.

2.1. Statistical models applied for the purpose and criteria of the Model's 'best fit'

Basic 11 statistical models used for the purpose in our study, along with their equations, are given below:

(*a*) *Linear Model* : $E(Y_t) = \beta_0 + \beta_1 t$

(*b*) *Logarithmic Model* : $E(Y_t) = \beta_0 + \beta_1 \ln(t)$

(*c*) *Inverse Model* : $E(t) = \beta_0 + \beta_1/t$

(*d*) *Quadratic Model* : $E(Y_t) = \beta_0 + \beta_1 t + \beta_2 t^2$

(*e*) *Cubic Model* : $E(Y_t) = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3$

(*f*) *Compound Model* : $E(Y_t) = \beta_0 \beta_1^t$

(*g*) *Power Model* : $E(Y_t) = \beta_0 t^{\beta_1}$

(*h*) *S Model* : $E(Y_t) = \exp(\beta_0 + \beta_1 / t)$

(*i*) *Growth Model* : $E(Y_t) = \exp(\beta_0 + \beta_1 t)$

(*j*) *Exponential Model* : $E(Y_t) = \beta_0 e^{\beta_1 t}$

(*k*) *Logistic Model* : $E(Y_t) = \left(\frac{1}{u} + \beta_o \beta_1^t\right)^{-1}$

Here, $\beta_0, \beta_1, \beta_2, \beta_3$ are coefficients, Y_t = Observed values; *for* $t = 1, 2, 3, \ldots, n$

and $E(Y_t) =$ *Expected values of* Y_t

Statistical analysis was performed using Software IBM SPSS 20 and the Excel. All the above 11 models were fitted to the observed data on height & weight by age (in months) for boys & girls below the age of 5 years for each of the 4 birth-weight categories in the Central Region of India. The goodness of the fit of the model was based on the highest value of R^2 the model, out of 11 of the models used. Applying this criterion, our analysis showed that only two statistical models - *the Cubic Model* and *the Power Model* fitted best to the data of various birth-weight categories, for estimating growth of boys and girls, below the age of 5 years, considering two anthropometric measurements – height & weight by their birth-weight for the Central Region of India. Results of only two best-fit models are given in the Results Section.

Here, birth-weight was categorized into 4 groups: <2000 gm, 2000–2499 gm, 2500–2999 gm and 3000 gm +. In Central Region, for weight of the boys.

a) At birth-weight <2000 gm,

Filter: Child's Age>0 & birth-weight=<2000 & Sex of Child=Male.

b) At birth-weight 2000–2499 gm,

Filter: Child's Age>0 & birth-weight=2000 – 2499 & Sex of Child=Male.

c) At birth-weight 2500–2999 gm,

Filter: Child's Age>0 & birth-weight=2500–2999 & Sex of Child=Male & child-weight< 30,000 was applied.

d) At birth-weight 3000 gm +

Filter: Child's Age>0 & birth-weight=3000+ & Sex of Child=Male

& child-weight<60,000 was applied.

For weight of the boys, in *(c) & (d) above*, filter was applied to exclude extreme values of more than 30,000 & 60,000 respectively.

Similarly, for the weight of the girls

a) At birth-weight <2000 gm,

Filter: Child's Age>0 & birth-weight=<2000 & Sex of Child=Female & child-weight<30,000 was applied.

b) At birth-weight 2000–2499 gm,

Filter: Child's Age>0 & birth-weight = 2000–2499 & Sex of Child = Female.

c) At birth-weight 2500–2999 gm,

Filter: Child's Age>0 & birth-weight=2500–2999 & Sex of Child=Female & child-weight<30,000 was applied.

d) At birth-weight 3000 gm +

Filter: Child's Age>0 & birth-weight=3000+ & Sex of Child=Female & child-weight<40,000 was applied.

For weight of the girls also, in *(a), (c) & (d) above*, filter was applied to exclude values of more than 30,000, 30,000 & 40,000 respectively.

3. Results

3.1. Socio-demographic characteristics and Under-5 Children's birth-weight

Table 1 shows distribution of under-5 children by their birth-weight categories and socio-demographic characteristics in Central Region of India.

Distribution of under-5 children by their age & birth-weight showed that 3.2%–4.4% children had their birth-weight below 2000 gm; 7.8%–10.6% children had their birth-weight between 2000 and 2499 gm; 18.4%–23.5% children had their birth-weight between 2500 and 2999 gm and 61.9%–70.6% children had their birth-weight either 3000 gm or more. Analysis showed that

Table 1
Under-5 children of different birth-weight categories by their socio-demographic characteristics in Central Region of India: National Family Health Survey – 4 (2015–16).

Socio-demographic Characteristics		Birth-weight (gm)								
		< 2000		**2000–2499**		**2500–2999**		**3000+**		**Total**
		u_1	%	u_2	%	u_3	%	u_4	%	N
Child Age (Months)		**Chi-square (df = 12) = 330.567, p = 0.000**								
	< 12	619	4	1634	10.6	3627	23.5	9564	61.9	15444
	12–23	555	4.4	1216	9.6	2806	22.3	8033	63.7	12610
	24–35	528	3.8	1293	9.4	2915	21.2	8992	65.5	13728
	36–47	478	3.3	1313	9.2	2737	19.1	9796	68.4	14324
	48–59	444	3.2	1103	7.8	2591	18.4	9939	70.6	14077
Sex of Child		**Chi-square (df = 3) = 33.234, p = 0.000**								
	Boys	1505	3.8	3517	8.9	7938	20.1	26567	67.2	39527
	Girls	1556	4.3	3501	9.7	7376	20.4	23685	65.6	36118
Birth Order		**Chi-square (df = 9) = 1359.274, p = 0.000**								
	1	1312	5.2	2780	10.9	6052	23.8	15265	60.1	25409
	2	868	4	2039	9.3	4876	22.3	14131	64.5	21914
	3	416	3.2	1105	8.6	2372	18.4	9026	69.9	12919
	4 & above	465	3	1094	7.1	2014	13.1	11830	76.8	15403
(Kg/m^2) **BMI**		**Chi-square (df = 9) = 68.093, p = 0.000**								
	< 18.5	883	4.5	1961	10	4135	21.1	12593	64.3	19572
	18.5–24.9	1792	3.8	4255	9	9457	20.1	31515	67	47019
	25.0–29.9	295	4.3	594	8.7	1286	18.9	4622	68	6797
	≥ 30	62	3.9	132	8.4	327	20.7	1058	67	1579
Highest Educational Level		**Chi-square (df = 9) = 1412.418, p = 0.000**								
	No Education	966	3.3	2332	8	4325	14.9	21456	73.8	29079
	Primary	519	4.1	1223	9.8	2483	19.8	8285	66.2	12510
	Secondary	1321	4.8	2856	10.3	6752	24.4	16747	60.5	27676
	Higher	255	4	607	9.5	1754	27.5	3764	59	6380
Respondent's Occupation		**Chi-square (df = 9) = 15.946, p = 0.068**								
	No Occupation	387	4.3	795	8.8	1823	20.3	5994	66.6	8999
	Others	55	5.2	80	7.6	234	22.1	690	65.2	1059
	Agriculture	78	4	171	8.8	382	19.6	1318	67.6	1949
	Don't know	1	1	5	4.8	31	29.5	68	64.8	105
Type of Place of Residence		**Chi-square (df = 3) = 287.694, p = 0.000**								
	Urban	847	4.9	1768	10.3	4070	23.7	10521	61.1	17206
	Rural	2214	3.8	5250	9	11244	19.2	39731	68	58439
Wealth Index		**Chi-square (df = 12) = 789.226, p = 0.000**								
	Poorest	841	3.3	2120	8.3	4224	16.6	18218	71.7	25403
	Poorer	738	4.1	1664	9.1	3602	19.8	12194	67	18198
	Middle	550	4.3	1264	9.9	2654	20.8	8276	64.9	12744
	Richer	506	4.9	1037	10.1	2380	23.1	6362	61.9	10285
	Richest	426	4.7	933	10.3	2454	27.2	5202	57.7	9015

Note: BMI = Body Mass Index, df = Degree of freedom, gm = Gram and m = meter.

Table 2
Models' summary for height of boys & girls by their birth-weight categories: National Family Health Survey - 4 (2015–16).

Birth – weight (gm)	Model	R^2	Constant	d. f.		f	b_1	b_2	b_3
				Regression	Residual				
Boys									
<2000	Cubic	0.811	53.795	3	1235	1771.274	1.739	−0.033	0.0002
2000–2499	Cubic	0.802	54.524	3	3167	4273.421	1.691	−0.03	0.0002
2500–2999	Cubic	0.832	55.124	3	7406	12256.29	1.667	−0.028	0.0002
3000 +	Cubic	0.796	56.014	3	23945	31147.41	1.602	−0.027	0.0002
Girls									
<2000	Power	0.817	44.612	1	1324	5891.892	0.186	–	–
2000–2499	Cubic	0.811	54.254	3	3193	4558.728	1.555	−0.025	0.0002
2500–2999	Cubic	0.826	53.445	3	6895	10877.75	1.763	−0.033	0.0002
3000 +	Cubic	0.79	55.051	3	21147	26445.01	1.53	−0.024	0.0001

Note: df = Degree of freedom and gm = Gram.

Table 3
Models' summary for weight (kg) of boys & girls by birth-weight categories: National Family Health Survey – 4 (2015–16).

Birth-weight (gm)	Model	R^2	Constant	d. f.		f	b_1
Boys				Regression	Residual		
<2000	Power	0.778	3030.168	1	1237	4323.331	0.364
2000–2499	Power	0.789	3306.981	1	3172	11895.39	0.343
2500–2999	Power	0.811	3485.011	1	7414	31890.88	0.333
3000 +	Power	0.763	3646.12	1	23975	77292.84	0.325
Girls							
<2000	Power	0.803	2641.494	1	1325	5394.646	0.389
2000–2499	Power	0.793	3133.014	1	3198	12362.17	0.345
2500–2999	Power	0.816	3202.653	1	6899	30568.71	0.346
3000 +	Power	0.771	336.144	1	21168	71163.55	0.337

Note: df = Degree of freedom and gm = Gram.

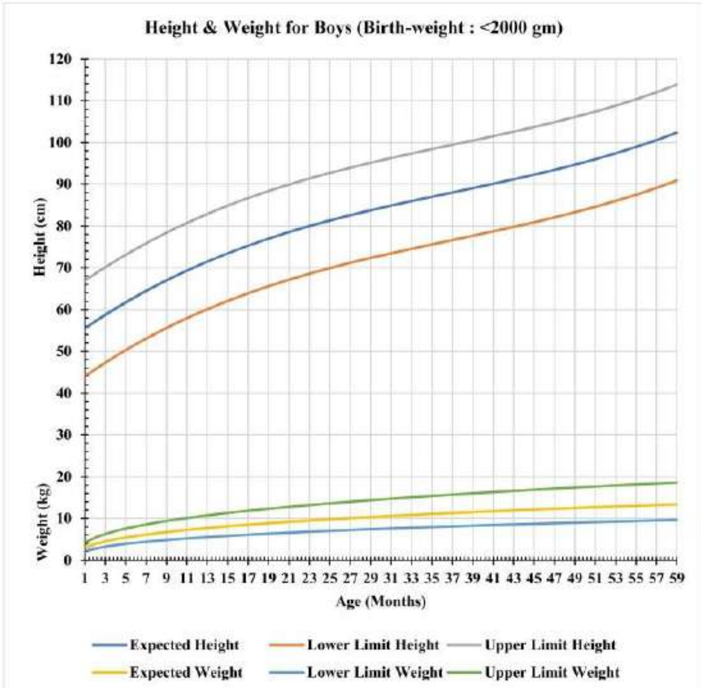

Fig. 1(a). National Family Health Survey-4 (Birth-weight <2000 gm): Estimated mean height and mean weight curves for boys of Central Region (India), using Cubic and Power Models respectively.

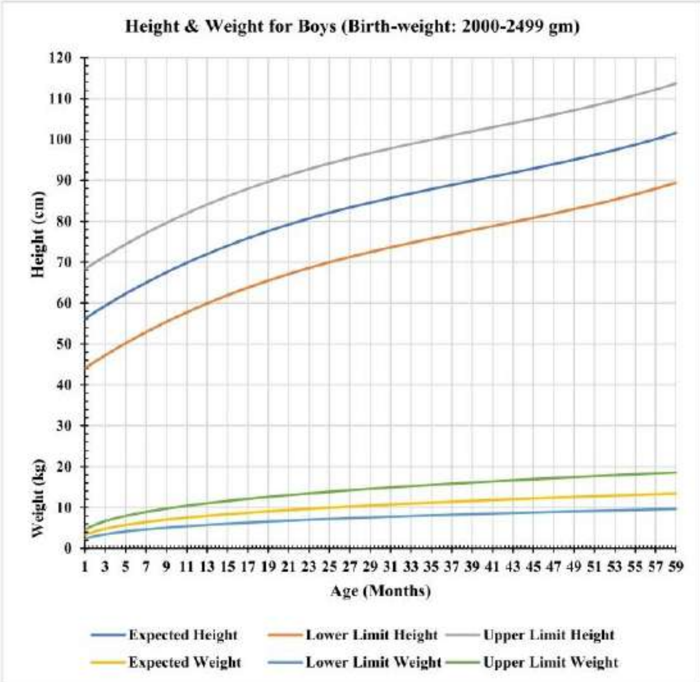

Fig. 1(b). National Family Health Survey-4 (Birth-weight 2000–2499 gm): Estimated mean height and mean weight curves for boys of Central Region (India), using Cubic and Power Models respectively.

children born in recent years had their birth-weight relatively lower than their counterparts. A significant association ($\chi^2 = 330.57$, $d.f. = 12$, $p < 0.001$) was observed between age of the children and their birth-weight. Also, more number of boys (67.2%) had their birth-weight of 3000 gm or more, than the girls (65.6%). Similarly, more number of girls had their birth-weight less than 3000 gm than boys. Like the age, sex was also found to be significantly associated ($\chi^2 = 33.23$, $d.f. = 3$, $p < 0.001$) with the birth-weight of the under-5 children.

Considering birth order, more children with higher birth order had birth-weight of 3000 gm & above and consequently, less number of children with higher birth-order had their birth-weight less than 3000 gm. Like age & sex, significant association ($\chi^2 = 1359.27$, $d.f. = 9$, $p < 0.001$) of birth-order was also observed with birth-weight of the under-5 children. For Body Mass Index (BMI), 3.9%–4.5% of under-5 children with different BMI scores had their birth-weight below 2000 gm; 8.4%–10.1% of the children had their birth-weight between 2000 gm and 2499 gm; 18.9%–21.1% of the children had their birth-weight between 2500 gm and 2999 gm. In these birth-weight categories, percentage of children decreased as the BMI score increased. Further, almost 64%–68% of the children belonged to the birth-weight category 3000 gm & above. Also, percentage of children increased with increasing BMI scores. BMI was also found to be significantly associated ($\chi^2 = 68.09$, $d.f. = 9$, $p < 0.001$) with birth-weights of the under-5 children.

Considering mother's highest education level, 3.3%–4.8% of the under-5 children had their birth-weight below 2000 gm; 8.0%–10.3% of the children had their birth-weight ranging from 2000 gm to 2499 gm; 14.9%–27.5% children had their birth-weight between 2500 gm and 2999 gm and 59.0%–73.8% children had their birth-weight of 3000 gm & above. Further, for children having their birth-weight below 3000 gm, percentage of children – belonging to different mother's highest education level categories, decreased as their education level increased. The situation was just reverse for children with birth-weight of 3000 gm & more. There was a significant association ($\chi^2 = 1412.42$, $d.f. = 9$, $p < 0.001$) between children's birth-weight and mother's highest level of education. Furthermore, when mother's occupation was considered vis-à-vis under-5 children's birth-weight, analysis showed that mother's occupation was not significantly associated ($\chi^2 = 15.95$, $d.f. = 9$, $p = 0.07$) with the children's birth-weight.

Analysis further revealed that respondent's two factors – place of residence as well as wealth index also played important role in the determination of their birth-weight. Findings showed that 4.9% urban and 3.8% rural under-5 children had their birth-weight below 2000 gm. For birth-weight groups (2000 gm – 2499 gm) and (2500–2999 gm), percentage of under-5 children was more from urban area than rural area. However, for the birth-weight group 3000 gm & above, the situation was just reverse. Place of residence of children was significantly associated ($\chi^2 = 287.69$, $d.f. = 3$, $p < 0.01$) with their birth-weight. For the wealth index also, our analysis revealed almost similar trend. Percentage of under-5 children in various wealth index categories

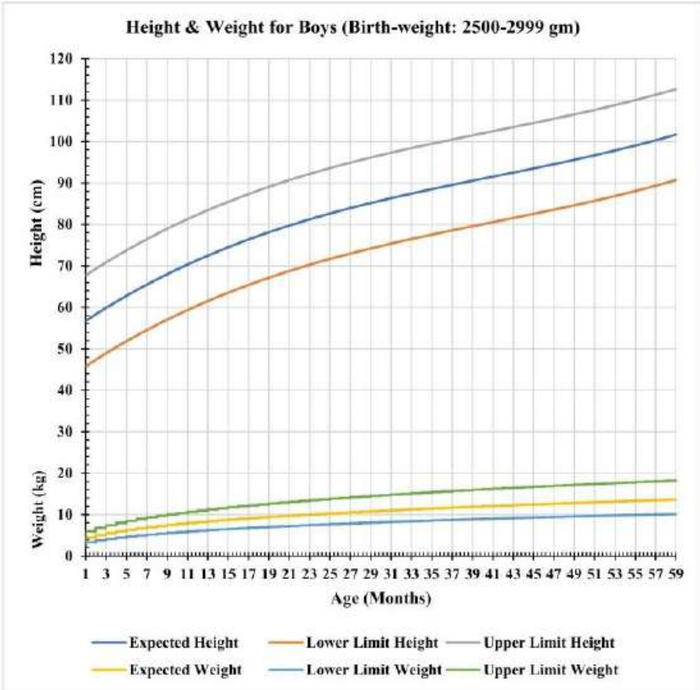

Fig. 1(c). National Family Health Survey-4 (Birth-weight 2500–2999 gm): Estimated mean height and mean weight curves for boys of Central Region (India), using Cubic and Power Models respectively.

increased with increase in their wealth status for all the birth-weight categories below 3000 gm. However, this trend was reverse for the birth-weight category 3000 gm & above, i.e., percentage of children in various wealth index categories decreased with increase in their wealth status. A significant association ($\chi^2 = 789.23$, $d.f. = 12$, $p < 0.01$) was seen between wealth index of the under-5 children and their birth-weight.

3.2. Growth Estimation of Under-5 children using statistical models

All the 11 statistical models, given above, were fitted to the height & weight data of children below 5 years of age from the Central Region of India to estimate the growth curves – considering their ages (in months) for all 4 birth-weight categories separately. Applying the criterion of the best-fit of the models, as given above, our analysis showed that only 2 statistical models, viz., - *Cubic Model* and *Power Model*, showed best-fit to the height & weight data of under-5 children, belonging to the different birth-weight categories, for estimating growth of boys & girls separately. Here, results of only 2 best-fit models have been shown below. (*Tables 2 & 3*).

Table 2describes models – summary for estimating height of boys and girls separately by birth-weight. Here, for height of the boys, considering Coefficient of Determinations (R^2) as the criterion for the best fit, *Cubic Model* fitted best for the birth-weight group 2500 gm – 2999 gm ($R^2 = 0.832$), followed by the group $< 2000\ gm$ ($R^2 = 0.811$), group $2000\ gm - 2499\ gm \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ ($R^2 = 0.802$), and then, birth-weight group 3000 *gm and above* ($R^2 = 0.796$). For height of the girls however, *Power Model* showed the best fit for the birth-weight group $< 2000\ gm$ ($R^2 = 0.817$) but for the rest of the three birth-weight groups, *Cubic Model* was the best fitted model. Thus, here, as per Coefficient of Determination (R^2), *Cubic Model* showed best fit ($R^2 = 0.826$) for birth-weight group 2500 – 2999 *gm*, followed by the group 2000 – 2499 *gm* ($R^2 = 0.811$) and then, group 3000 *gm and above* ($R^2 = 0.790$).

Table 3 describes models – summary for estimating weight of the boys & girls separately by birth-weight. For weight of the boys as well as girls, best fitted model was the *Power Model*. Further, considering boys, as per the Coefficient of Determination (R^2), this Model fitted best for birth-weight group 2500 – 2999 *gm* ($R^2 = 0.811$), followed by the group 2000 – 2499 *gm* ($R^2 = 0.789$), group $< 2000\ gm$ ($R^2 = 0.778$) and the birth-weight group 3000 *gm and above* ($R^2 = 0.763$). For estimating the weight of the girls, *Power Model* showed best fit for the birth-weight group

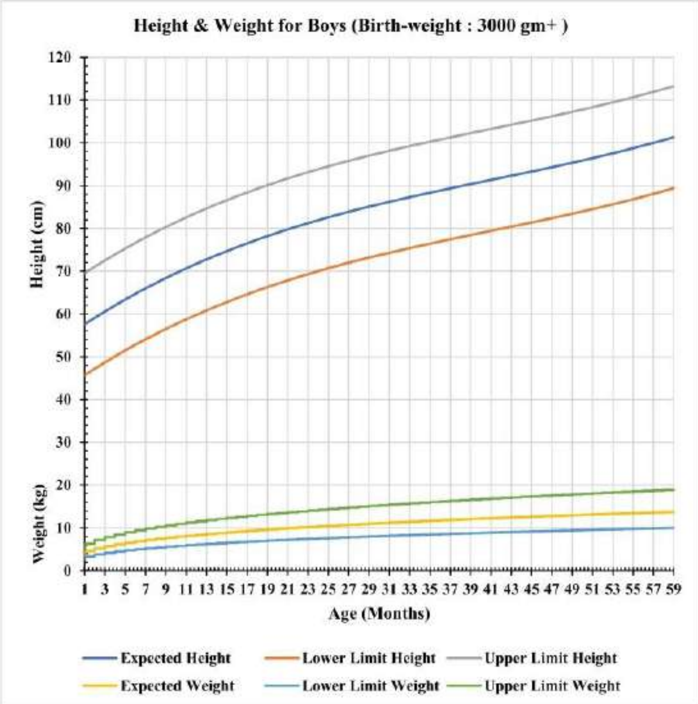

Fig. 1(d). National Family Health Survey-4 (Birth-weight 3000+ gm): Estimated mean height and mean weight curves for boys of Central Region (India), using Cubic and Power Models respectively.

2500 – 2999 *gm* ($R^2 = 0.816$), followed by the group < 2000 *gm* ($R^2 = 0.803$), group 2000 – 2499 *gm* ($R^2 = 0.793$) and then, birth-weight group 3000 *gm and above* ($R^2 = 0.771$).

3.3. Estimated mean height & weight curves for boys & girls for the Central Region of India

We estimated growth values – considering mean height and mean weight of under-5 children for their ages – ranging from 1 to 59 months, considering all four birth-weight groups, viz. < 2000 *gm*, 2000 – 2499 *gm*, 2500 – 2999 *gm* & 3000 *gm & above*, by using *Cubic Model or Power Model* which ever fitted best under the situation, for boys and girls separately. Therefore, growth charts – in terms of mean height and mean weight curves, were drawn for each of the birth-weight group and for two sexes separately (Figs. 1a, 1b, 1c, 1d, 2a, 2b, 2c and 2d). *Fig.* 1(*a*) *to Fig.* 1(*d*) show estimated mean height and mean weight curves of boys for each of the four birth-weight groups separately. Similarly, such estimated mean height and mean weight curves for girls for all four birth-weight groups are shown in *Fig.* 2(*a*) *to Fig.* 2(*d*). The graphs shown here, besides giving estimated mean height and mean weight curves in each case, also give curves for 95% upper as well as lower confidence limits. Thus, from the curves given in *Fig.* 1(*a*) *to Fig.* 1(*d*) and *Fig.* 2(*a*) *to Fig.* 2(*d*), it is possible to obtain not only the expected growth values of under-5 children in terms of their mean height and mean weight for their ages (months) in each case but also their 95% upper & lower confidence limits.

4. Discussion

Inadequate growth during childhood adversely affects the later health outcomes. Child growth needs are to be monitored by the family and child specialist. It is also considered as an indicator of health and its secular trend demonstrates the level of population health. India is in phase of nutritional transition and as such, it is vital for the country to have updated growth references. In studying child-growth, we often make use of 'growth standards' and 'growth references'. These two terms are different concepts. Growth standards define how a population of children should grow - given optimal nutrition as well as optimal health, whereas 'growth references' are always descriptive and prepared from a population which is thought to be growing in the best possible state of nutrition and health in a given community [4]. Further, pattern of growth of children changes with time and as such, their growth

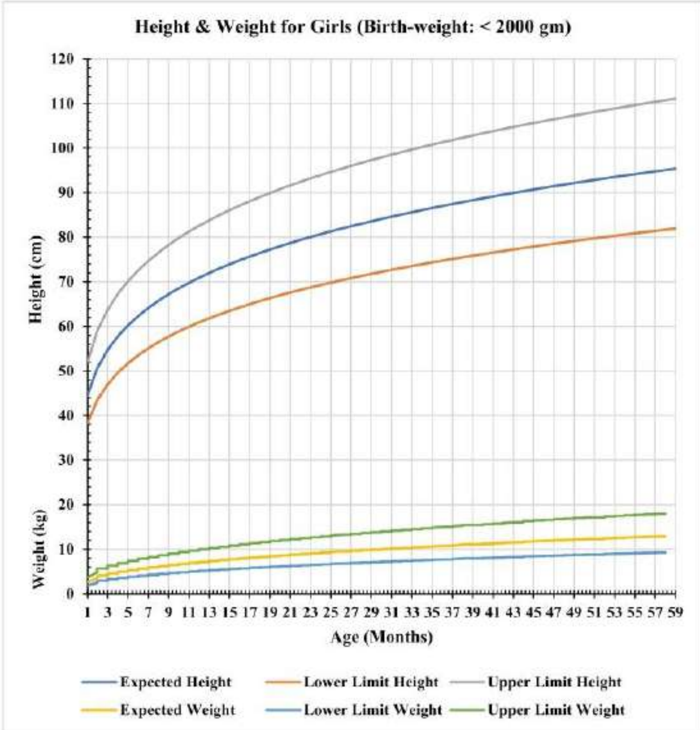

Fig. 2(a). National Family Health Survey-4 (Birth-weight < 2000 gm): Estimated mean height and mean weight curves for girls of Central Region (India), Using Power Model.

references should regularly be updated. Furthermore, for proper assessment of the growth pattern of children, their comparison – considering relevant anthropometric measurements is needed from the available growth references.

The growth references, quite often, are the children of the same age & sex from the well-to-do families – either from the same or the national population. However, when the suitable local or national growth references are not available, such comparisons are, at times, made using the growth standards, like the WHO. In 2006/2007, WHO released updated growth and development criteria for children under the age of five years, as well as growth standards for school-aged children and adolescents, based on the Multicentre Growth Reference Study (MGRS) [2]. Based on this criterion, nearly 30% of pre-school children in Developing Countries were found to have stunted growth as a result of local environmental factors - mostly poor nutrition and illnesses [3]. Child development failure has been responsible for more than 23% of under-5 mortality in the Region, making it the second greatest cause of child mortality [7].

Birth-weight is often considered as a key indicator of the health trend in a child. It has been found to be a predictor of Protein Energy Malnutrition (PEM) [8]. Birth-weight is also considered to be the single-most determinant of the chances of new-born's survival and for healthy growth and development. In our study, we analysed National Family Health Survey-4 data to investigate association between selected socio-demographic factors and birth-weight of the under-five children of the Central Region of India. Our results demonstrated significant association of 7, out of 8 socio-demographic factors studied, namely – age & sex of the child, birth-order, BMI, mother's highest level of education, place of residence and wealth index.

Borah and Agrawal [9] in their cross-sectional study undertaken in a rural Block of Assam in India – based on their 450 randomly selected infants from 30 villages, found illiterate – teenage mothers, grand multi-para, short inter-pregnancy intervals and anaemic mothers to be the important risk factors of the low birth-weight. Similarly, another study by Mishra et al. [10] tested a hypothesis of no association between socio-economic status of households and new-borns' low birth-weight in India. The study demonstrated that under-weight & rural women and women with no or primary education, low BMI, unclean cooking fuel and those from northern & eastern region of the country had higher share of low birth-weight. This study also revealed that female children,

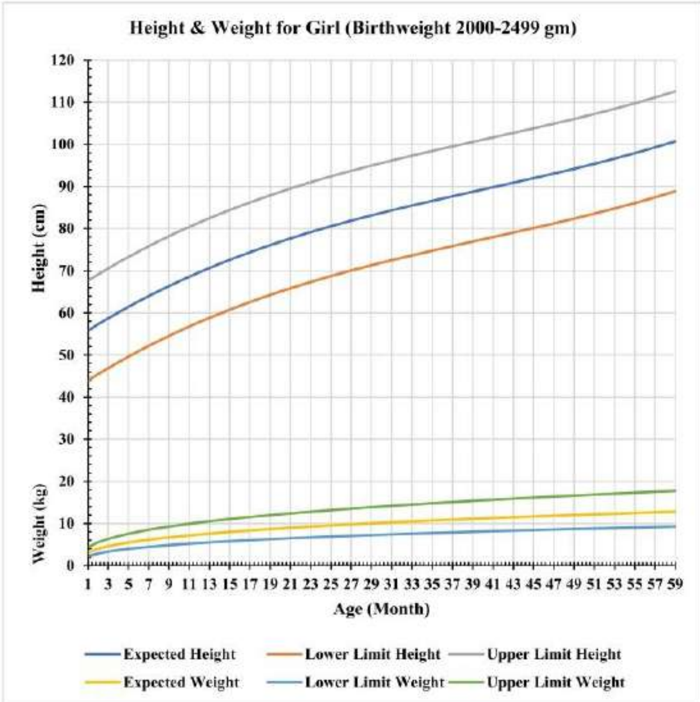

Fig. 2(b). National Family Health Survey-4 (Birth-weight 2000–2499 gm): Estimated mean height and mean weight curves for girls of Central Region (India), Using Cubic and Power Models, respectively.

children from 4th birth-order & with birth interval of less than 24 months and those with no improved toilet facility had greater share of low birth-weight than their counterparts.

Statistical growth modelling approach is a powerful tool for the studying growth of the children and their growth trajectories. It consists of fitting models to physical growth data (such as - weight & height) to obtain appropriate growth curves. Our results showed that only two models, viz. — the Cubic Model and the Power Model, out of the 8 basic statistical models applied to the data, demonstrated best-fit to the height & weight data of under-five children, belonging to the different birth-weight categories, for estimating growth of boys & girls separately. These models enabled us to estimate mean height and mean weight values of boys and girls against their ages (1 month–59 months) by different birth-weight categories along with their 95% upper and lower limits. These growth–curves are likely to be quite useful in estimating mean values of height and weight for given birth-weights of under-five boys & girls.

In a growth-study using modelling approach [7], the Jenss-Bayley Model, Reed model, and Gompertz functions were some of the structural and non-structural growth models that have been used to describe child growth. One rationale for fitting models to growth data is that a suitable curve will neatly encapsulate the information offered by an individual child's observations [11]. Not only this, models also generate smooth curves of status as well as of velocity — even from irregularly spaces measurements. By using parametric estimates, one can have more estimates between families of curves. The Jenss-Bayley Model here presented the best fit for weight and height, both for boys and girls [7]. Mean height growth trajectories were identical in shape and direction for boys and girls while the mean weight growth curve of girls fell slightly below the curve of boys after neonatal life [7].

Similarly, Berkey [11] compared two statistical models, viz. the Count Model — a linear model, and the Jenss Model — a non-linear model, for growth in length and weight of the pre-school children in United States. These models were fitted to the large data of length and weight and the results were used to study efficiency, reliability and goodness-of-fit of the models. The author [11] showed that the Count Model did not adequately fit to the data while the Jenss Model performed well for both - length and weight.

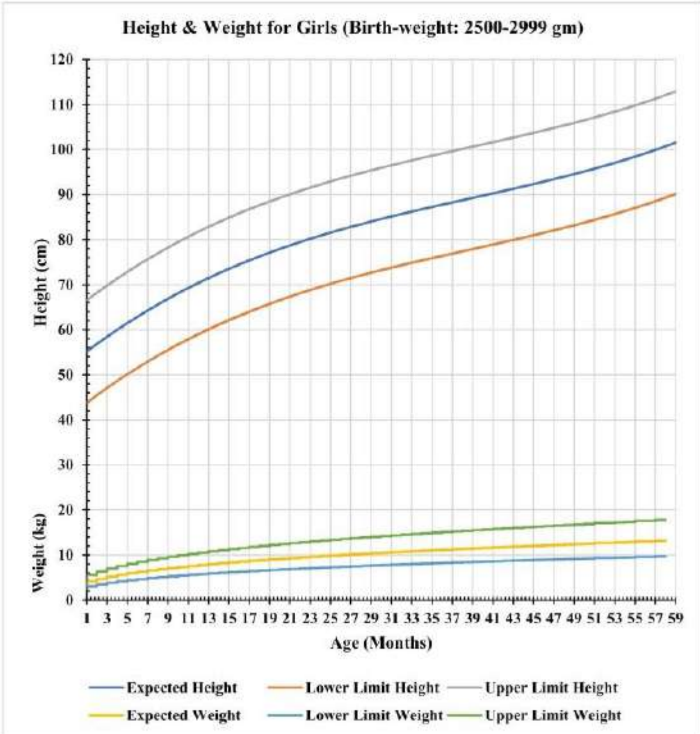

Fig. 2(c). National Family Health Survey-4 (Birth-weight 2500–2999 gm): Estimated mean height and mean weight curves for girls of Central Region (India), using Cubic and Power Models, respectively.

of the pre-school children.

For assessment of height, weight and BMI, WHO growth standards (for children <5 years) and contemporary cross sectional reference percentile curves (for children from 5 to 18 years) are available for clinical use and for research purposes [4] Further, in growth studies - dealing with height and weight measurements and using statistical modelling approach, modelling weight is often more difficult than height, because weight of children might decrease with age for shorter periods. This however, may not be the case with their height.

Children's growth patterns in India have been influenced by the country's rapid economic and social transformation, particularly in urban regions [5]. According to recent Indian studies [5,6], there is a trend toward increased height, particularly in boys, as well as an increase in obesity in both genders. Since 2010, the Indian Government have approved the WHO 2006 growth guidelines for measuring the growth of children under the age of five years [5]. Khadilkar et al. [6] studied nutritional status of Indian pre-school children – taking data from NFHS - 4 and using WHO (2006) and Indian synthetic charts (2019). They calculated z scores of length/heights, weight and weight–for-height, using both the charts. It was concluded that use of Indian synthetic charts for growth monitoring of under-five children may be more appropriate and that, infants below 6 months and children from well off families performed well.

In the present study, National Family Health Survey – 4 data of the under-five children for the Central Region of India have been used. These data were used for estimating child growth curves – considering mean height & mean weight for boys & girls separately by birth-weight, applying the Cubic Model and the Power Model wherever these fitted best. In fact, several factors may play a role in the goodness of fit of any model. Even quality of data also influences model's goodness of fit since several measurement errors increase residuals [3]. As explained above, the National Family Health Survey - 4 data, used in the present study, are from the Government Departments and as such, these are of high quality and also nationally representative. Thus, in testing goodness of fit of the various models used in our study, the role of the quality of data might not have played much role.

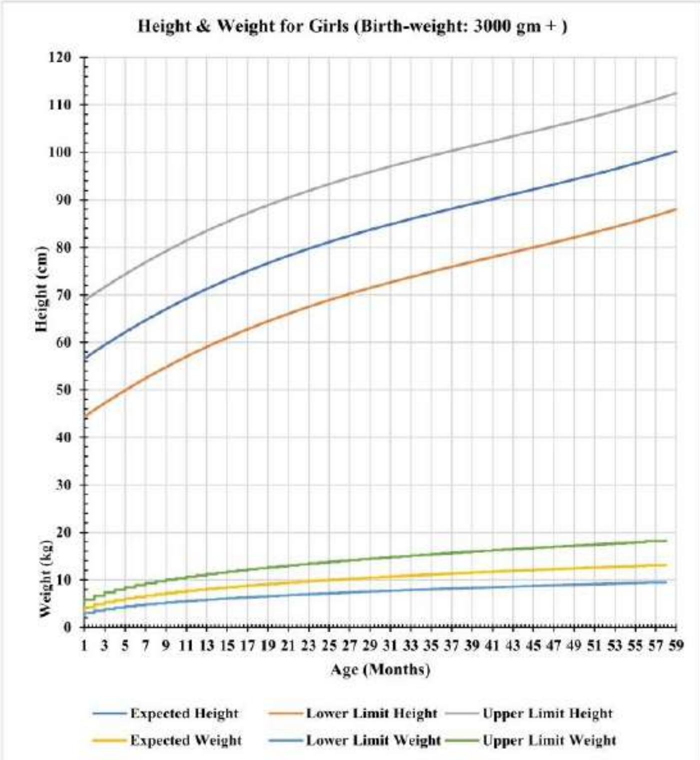

Fig. 2(d). National Family Health Survey –4 (Birth-weight 3000+ gm): Estimated mean height and mean weight curves for girls of Central Region (India), using Cubic and Power Models, respectively.

5. Conclusions

Our study concluded that 7 socio-demographic factors, namely - age & sex of the children, their birth-order & BMI and mothers' highest level of education, their place of residence and the wealth index were significantly associated factors with the birth-weight. Further, the Cubic Model and the Power Model were most suitable for estimating child growth in terms of height & weight for boys and girls – considering specific birth-weight categories. The estimated growth charts of the mean height & mean weight for pre-school boys & girls of the Central Region of India are likely to be quite useful in the Indian growth studies.

6. Limitations

The estimated growth curves of under - 5 children, obtained in this paper, need to be seen with some limitations. As already mentioned, this study on growth of pre-school children, is based on secondary data, taken from the National Family Health Survey – 4 of India. A major disadvantage of the secondary data is that it may not answer authors' specific research questions and that; analyst does not know how well the data collection process was completed. Resultantly, he is not aware of on how seriously the data were affected by factors, such as - low response rate or respondents' misunderstanding of specific survey questions. Our results thus, suffer from disadvantages, similar to those mentioned above, which are common to secondary data-based studies.

Under – 5 children of the present study belong to the 3 States of India, namely – Chhattisgarh, Madhya Pradesh & Uttar Pradesh. The estimated growth curves, obtained here, can thus be used for under - 5 children from these States only. Further, our estimated growth curves are derived for height & weight only for boys & girls separately when their birth-weight categories are known. Therefore, the obtained growth charts can be used for the two anthropometric measures of under – 5 children, namely - height & weight only, when they are from above 3 States and when their birth-weights along with ages & sexes are known.

Competing interests

The authors declare that they have no conflict of interest.

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Author contribution

Pradyuman Verma, Jang Bahadur Prasad and Noel George contributed to the design of the study and drafted the manuscript and did analysis as well as interpretation. Pradyuman Verma was involved in the review and gathering the published studies. Furthermore, authors approved the final manuscript.

Consent to participate (ethics)

The study publicly available published previous articles.

Consent to publish (ethics)

Not applicable.

Declaration of competing interest

This is to certify that we the authors of article hereby declare that we do not have any conflict of interest in the article entitled **"Growth Estimation of Under-Five Children Using Statistical Models in Central Region of India"**.

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Review

Stunting, wasting and underweight as indicators of under-nutrition in under five children from developing Countries: A systematic review

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ABSTRACT

Background and aims: To compute reliable estimates of stunting, wasting and underweight along with their determinants in under 5 children from Developing Countries.
Methods: Out of 190 studies on under-nutrition, accessed from PubMed and Google database, 24 studies meeting the selection criteria were considered for meta-analysis.
Results: Overall estimate of prevalence of stunting, wasting and underweight were 43.4%, 17.8% and 35.5% respectively. Mother's education, BMI, height, wealth index, child birth-weight and sex were factors significantly associated with stunting, wasting and underweight.
Conclusions: Prevalence of stunting, wasting and underweight in Developing Countries were quite high. To carry-out differentials of under-nutrition between countries and ways of its reduction, more such studies are required.

1. Introduction

Malnutrition is a major underlying cause of the child morbidity and mortality in India and also in many other Developing Countries. It refers to inadequate dietary intake, presence of any infectious disease, or combination of the two. It can exacerbate the impact of a disease also. Nearly one-half of all child deaths globally are attributable to this cause. Child malnutrition also draws parallel links with their demographic features, environmental & socioeconomic conditions, parental characteristics and household possession as well as their geographical location [1]. It is caused by various interlinked factors and has both - short as well as long term harmful health effects. Under-nutrition accounts for at least half of all the deaths annually in children under-5 years of age worldwide. Even today, it is a serious public health problem amongst children below 5 years of age in India and also in several other Developing Countries [2]. Stunting, wasting and underweight are three broadly known indicators of child nutritional status.

Globally, prevalence of stunting, underweight, and wasting in children less than 5 years of age have been reported to be 26%, 16% and 8% respectively [3]. WHO has estimated that approximately 150–200 million children, aged below 5 years of age in Developing Countries were underweight and stunted [3]. It has also been estimated that nearly one out of every eight of the under 5 children dies due to malnutrition in Sub-Saharan Africa [3]. Stunting - a measure of chronic undernutrition, is the most prevalent form of child under-nutrition in Developing Countries. The worldwide prevalence of stunting amongst under 5 children, by & large, has decreased in past recent years. In 2012, WHO had set a global target to reduce the number of stunted children by 40% from the baseline of 171 million in 2010 to 100 million by 2025 [4].

In SEA Region too, malnutrition has been seen as a serious public health problem, particularly for under 5 children. For example, almost 50% of total deaths among children under 5 were attributable to under-nutrition in Myanmar [5]. Similarly, in 2007 in Bangladesh [6], 43% of under-five children were stunted and the proportion was about 24% higher in rural areas than in the urban areas. Bangladesh had achieved a lower stunting rate of 41% in 2011 and this further improved to 36% in 2014, compared to higher average income countries such as Pakistan (45% stunting in 2012) and India (38.4% stunting in 2017). In fact, nutrition in children, compared to other population-groups, becomes a serious concern because childhood is an intense period of mental, physical, and cognitive growth and that, it is highly predictive of future health [7]. Macronutrient and micronutrient deficiencies are common during childhood with stunting, wasting, and underweight being the most common nutritional problems affecting millions of

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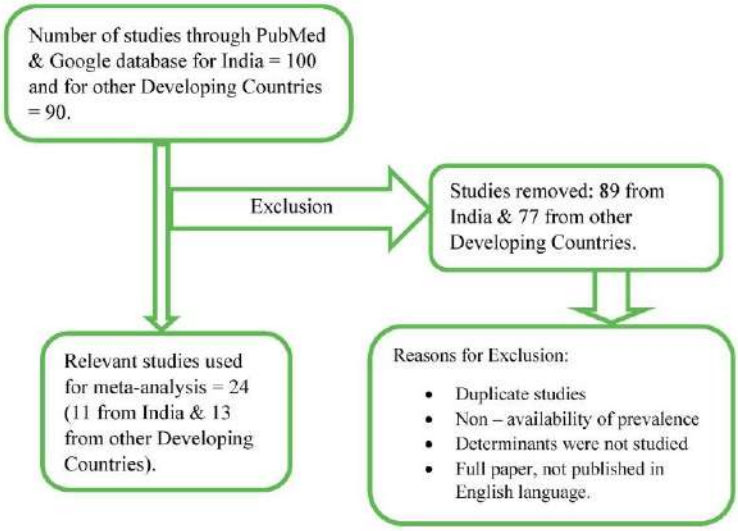

Fig. 1. Flow Chart of the selection process of published studies on stunting, wasting & under-weight in under 5 children for the meta-analysis.

children worldwide. Stunting is a global nutritional challenge that disproportionately affects Developing Nations [7].

In recent years, prevalence of childhood stunting and underweight in India also remained persistently high [8]. In 1992–93, amongst children aged 0–47 months, 57% and 49% children were stunted and underweight respectively, declining to 47% and 42% respectively in 2005–2006, and further, to 39% and 29% respectively in 2013–14. In 2011, India accounted for 38% of the global burden of stunting (nearly 62 million children) under-scoring importance of reducing undernutrition in India [8]. Our country bears more than one third of the global burden of child stunting. Within the country, the National Nutrition Strategy (NNS), released by the NITI Aayog in 2017, specifically aimed to prevent and reduce prevalence of underweight in children (0–3 years) by 3% points per annum by the year 2022.

A NFHS study in India [9] reported that prevalence rates of underweight, stunting, and wasting were 43%, 48%, and 20%, respectively among children younger than 5 years in rural areas. Prevalence of under-nutrition among under5 children, according to some other similar studies in India [10,11] showed that 35.7% under five children were underweight, 38.4% were stunted and 21% were wasted. The Government of India is strongly committed to achieving by 2030 Sustainable Development Goals (SDGs) [12]. In India, despite a declining trend observed in prevalence of undernutrition, more than 30% of children under5 years of age are still stunted and underweight [13].We conducted a study of systematic review on above 3 indicators of under-nutrition to obtain a reliable pooled estimates of prevalence of stunting, wasting and underweight for selected Developing Countries including India.

2. Material & methods

2.1. Literature review

A literature search was carried out, using Pub Med and the Google data-base, to identify articles, published during a period of 12 years (2009–2020) from Developed Countries including India, on stunting, wasting and underweight. The key-words used for searching these articles were 'stunting', 'wasting' and 'underweight', 'under 5 children' and 'Developing Countries'. Number of studies, initially considered for this purpose, process of their selection, and studies finally selected for the meta-analysis, are explained in the Flow Chart (Fig. 1).

2.2. Inclusion and exclusion criteria

In the present study, only those published studies, which had similar methodology and criteria for inclusion & exclusion of children, were considered for the purpose of meta-analysis. An additional condition was also considered in the literature search that study's full published paper in English language was available. The cross - references of the enlisted articles, used if any, were also accessed through Google data-base, for the purpose of the present study.

2.3. Data extraction

Data extraction from each selected study included authors' last name, year of publication, its place and sample size (n), prevalence rate along with standard error of stunting, wasting & underweight and factors — found to be significantly associated with them. The extracted data were then analysed for calculating estimates of prevalence of above 3 indicators of under-nutrition with their 95% confidence intervals.

2.4. Statistical analysis

Studies conducted in different parts of the globe and finally selected for the purpose of present study, as shown in Fig. 1, constituted the material of the present study. The 24 studies selected for the meta-analysis, were finally reviewed and their *Forest* as well as *Funnel Plots* were drawn. STATA 16 Statistical

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Table 1
Prevalence of stunting (%) in under 5 children, found in selected studies from India and some other Developing Countries.

Authors	Region	Sample Size (n)	Stunting		Factors found significantly associated with the prevalence rate
			Prevalence (%)	S.E.	
Studies from India:					
Corsi et al., 2015	India	51,555	51.1	0.22	Household wealth quintile, mother's education, mother's BMI, dietary diversity score, short maternal stature
Kim et al., 2019	India	1,40,444	38.62	0.13	Maternal height, maternal educational, maternal BMI, household wealth quintile, sanitary facility, ante-natal care visits, skilled birth attendant at delivery, stool disposal & breastfeeding initiation
Ghosh & Varerkar 2019	Maharashtra (India)	718	59	1.84	Age group, weaning age, household size
Meshram et al., 2012	India	14,587	51	0.41	Age, gender, family size, literacy status of parent, household wealth index, history of morbidity
Meshram et al., 2014	Odisha (India)	1951	65	1.08	Age, religion, literacy status of parents and household index
Rajaram et al., 2016	India	51,555	44	0.22	Healthcare, movement, Money
Akhade et al., 2019	India	400	36.5	2.41	Age, birth-weight, sought medical opinion
Huey et al., 2019	Mumbai (India)	323	31.2	2.58	Sex, birth-weight, haemoglobin, income, maternal height, maternal education
Murarkar et al., 2020	Maharashtra (India)	3671	45.9	0.82	Sex, birth order, type of family
Meshram et al., 2012	Maharashtra (India)	1751	61	1.17	Age, gender, household's wealth index
Jeyakumar et al., 2019	Pune (India)	400	34	2.37	Age, birth weight
Studies from Some Other Developing Countries:					
Khan et al., 2019	Pakistan	3071	44.4	0.90	Residence, mother's education level, consanguineous marriage, wealth index, mother's height, age of child, child size at birth
Sulaiman et al., 2018	North Sudan	1447	42.5	1.30	Age, gender
Hagos et al., 2017	Ethiopia	1,99,771	43.7	0.11	Age of the child, sex of the child, place of delivery, mother's education, household food insecurity
Khaing et al., 2019	Myanmar	4286	29.1	0.69	Child's age, child's gender, preceding birth interval, mother's BMI, parent's education, birth-weight, socio-demographic status
Bhowmik & Das 2018	Bangladesh	6931	36	0.58	Child-level factors: age, birth interval and incidence of diarrhoea. Mother-level factors: age, education and nutrition status. Household-level factors: economic status. Community-level factors: place of residence, and regional factors
Upadhyay & Bhusal 2017	Nepal	2334	41	1.02	Wealth index, size of child at birth, mother's smoking habit, ANC check-up, mother's height, mother's BMI
Sapkota & Gurung 2009	Nepal	150	37	3.94	Sex of the child, ethnicity, socio-economic status,
Mengesha et al., 2020	Ethiopia	7909	39.2	0.55	Maternal height, age of the child, weight of child
Chowdhury et al., 2016	Bangladesh	7568	41.3	0.57	Children's age group, mother's BMI, father's educational status, place of residence, socio-economic status, religion and food security
Mengistu et al., 2013	Hidabu Abote (Ethiopia)	820	47.6	1.74	Child age, family monthly income, pre-lactation foods/fluids
Tiwari et al., 2014	Nepal	2380	40.6	1.01	Currently breastfeeding, duration of breastfeeding, perceived size of baby at birth, wealth index, child's age in month, ecological zone
Das & Gulshan 2017	Bangladesh	17,989	36.2	0.36	Age of child, place of residence, division, father's education, mother's education, father's occupation, mother's occupation, mother's BMI, wealth index, toilet facility, number of living children & birth order.

Software was used for describing the pooled estimates of prevalence of stunting, wasting & underweight, obtained from individual studies. Spread was measured around the weighted pooled estimates of prevalence of the above 3 indicators of under-nutrition. The heterogeneity in stunting, wasting as well as in underweight in the given study was described by I^2 statistics ($I^2 < 50\%$ indicated low heterogeneity and $I^2 \geq 50\%$ indicated high heterogeneity).

$$I^2 = \frac{Q - d.f.}{Q} \; X \; 100$$

where *Q statistic* has k-1 d. f.

$$Q = \frac{\sum_{i=1}^{N} \left(\hat{b}_i - \hat{\bar{b}}_i \right)}{\hat{\sigma}_i^2}$$

Here $\hat{b}_i$ = *Estimated effects, which vary from study to study*

σ_i = *Standard Error of estimated effect*

$\hat{\bar{b}}_i$ = *Precision − weighted average of the estimated effects*

$$\hat{\bar{b}}_i = \frac{\sum_{i=1}^{N} \hat{\sigma}_i^{-2} \hat{b}_i}{\sum_{i=1}^{N} \hat{\sigma}_i^{-2}}$$

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Table 2
Prevalence of wasting (%) in under 5 children, found in selected studies from India and some other Developing Countries.

Authors	Region	Sample Size (n)	Wasting		Factors found significantly associated with the prevalence rate
			Prevalence (%)	S.E.	
Studies from India:					
Kim et al., 2019	India	1,40,444	19.56	0.11	Maternal BMI, maternal height, household wealth quintile, dietary diversity score
Ghosh & Varerkar 2019	Maharashtra (India)	718	20.00	1.49	Age group
Meshram et al., 2012	India	14,587	22	0.34	Family size, literacy status of parent, household's wealth index, history of morbidity
Meshram et al., 2014	India	1951	20	0.91	Age, literacy status of father, household wealth index, and morbidities during the preceding fortnight
Rajaram et al., 2016	India	51,555	18	0.17	Autonomy
Akhade et al., 2019	India	400	24.8	2.16	% of RDA consumed, primary immunization, maternal education, maternal employment, maternal nutrition status
Huey et al., 2019	Mumbai (India)	323	9	1.59	Sex, birthweight, cough, fever, maternal age, maternal height
Murarkar et al., 2020	Maharashtra (India)	3671	17.1	0.62	Breastfeeding, diarrhoea
Meshram et al., 2012	Maharashtra (India)	1751	29	1.08	Gender, morbidity
Jeyakumar et al., 2019	Pune (India)	400	15.3	1.80	Age, birth-weight, colostrum feeding, time of introduction of complementary feeds
Studies from Some Other Developing Countries:					
Khan et al., 2019	Pakistan	3071	10.7	0.56	Mother's education level, mother's BMI
Sulaiman et al., 2018	North Sudan	1447	21	1.07	Age, gender
Khaing et al., 2019	Myanmar	4286	6.8	0.38	Child's age, mother's BMI, father's education, sociodemographic status
Upadhyay & Bhusal 2017	Nepal	2334	29	0.94	size of child at birth, child's sex, mother's BMI
Sapkota & Gurung 2009	Nepal	150	11	2.55	None
Chowdhury et al., 2016	Bangladesh	7568	15.5	0.42	Mother's BMI, region of residence
Mengistu et al., 2013	Hidabu Abote (North Shewa)	820	16.7	1.30	Treatment of drinking water by any means
Das & Gulshan 2017	Bangladesh	17,989	15	0.27	Age of child, sex of child, place of residence, division, mother's BMI, and wealth index
Akombi et al., 2017	Nigeria	24,529	18	0.25	Type of residence, geo-political zones,/mode of delivery, perceived birth size, father's & mother's education, mother's BMI, type of delivery assistance & size of child

I^2- tells the percentage of the variability in effect estimates, i.e., due to heterogeneity rather than chance (or sampling error).

The weighted estimates of prevalence of stunting, wasting & underweight with 95% confidence intervals were computed, in addition to the *Funnel Plot* and *Egger's Test*, to study the publication preferences.

3. Results

Out of available 190 studies, published from Developing Countries including India, as filtered from PubMed and the Google database, only 24 confirmed to our selection criteria and hence, were included for meta-analysis in the present study (Fig. 1). The pooled prevalence rates of stunting, wasting as well as underweight - the 3 indicators of under-nutrition, were estimated from datasets, retrieved from the above 24 studies [1–24].

i) **Pooled Estimate of Prevalence for Stunting in Under Five Children**: Data for meta-analysis (Table 1) showed that prevalence (%) of stunting varied with geographical region. In India, prevalence of stunting was highest in Odisha (65%), followed by Maharashtra (59%). Prevalence of stunting was lowest in Mumbai (31.2%). In other Developing Countries, prevalence of stunting was highest in Hidabu Abote District, Ethiopia (47.6%), followed by Pakistan (44.4%) and Ethiopia (43.7%) and it was lowest in Myanmar (29.1%).

Fig. 2a showed the *Forest Plot* of stunting in fewer than 5 children from India and some other Developing Countries, giving distribution of prevalence rates - based on 11 studies and 12 studies respectively. Within India, highest prevalence estimate for stunting was 65% (95% CI: 62.88, 67.12) and lowest was 31.2% (95% CI: 26.15, 36.25). Overall pooled estimate of prevalence rate for stunting was 47.14% (95% CI: 40.44, 53.84), with heterogeneity in prevalence rates amongst 11 studies being high ($I^2 = 99.89\%$ *and* $p = 0.00$). For other Developing Countries, highest estimate of prevalence rate for stunting was 47.60% (95% CI: 44.18, 51.02) in Hidabu Abote (Ethiopia) and lowest was 29.10% (95% CI: 27.74, 30.46) in Myanmar. However, overall pooled prevalence estimate for stunting was 39.90% (95% CI: 37.11, 42.68), with heterogeneity of prevalence estimate amongst 12 studies being high again ($I^2 = 98.82\%$ *and* $p = 0.00$). Fig. 2b showed evidence of publication bias in above studies on stunting. As can be seen, the *Funnel Plot* doesn't exhibit the expected normality in the estimates of stunting. Furthermore, there are fluctuations in the spread of the prevalence rates of stunting which is more on the upper side of the estimates.

Table 3
Prevalence of under-weight (%) in under 5 children, found in selected studies from India and some other Developing Countries.

Authors	Country	Sample Size (n)	Underweight		Factors found significantly associated with prevalence rate
			Prevalence (%)	S.E.	
Studies from India:					
Corsi et al., 2015	India	51,555	44.9	0.22	Household wealth quintile, mother's education, dietary diversity score, short maternal status
Kim et al., 2019	India	1,40,444	34.19	0.13	Household wealth quintile, maternal education, maternal BMI, household air quality, antenatal care visits, dietary diversity score, stool disposal, skilled birth attendant at delivery
Ghosh & Varerkar. 2019	Maharashtra (India)	718	53	1.86	Age group, household size, health status
Meshram et al., 2012	India	14,587	49	0.41	Age, gender, family size, literacy status of parent, household wealth index, history of morbidity
Meshram et al., 2014	Odisha (India)	1951	58	1.12	Religion, household wealth index, literacy status of parents and history of morbidities during preceding fortnight
Rajaram et al., 2016	India	51,555	37	0.21	Healthcare, movement, money
Akhade et al., 2019	India	400	39.8	2.45	Family size, type of delivery, initiation of breastfeeding, medical education, maternal nutritional status, maternal dietary intake (% of RDA)
Huey et al., 2019	Mumbai (India)	323	25.1	2.41	Sex, birthweight, cough, fever, maternal height, maternal education
Murarkar et al., 2020	Maharashtra (India)	3671	35.4	0.79	Breastfeeding, income of family, maternal education
Meshram et al., 2012	Maharashtra (India)	1751	64	1.15	Gender, education of mother, acute respiratory infections
Jeyakumar et al., 2019	Pune (India)	400	21.8	2.06	Birth-weight, immunization status
Studies from Some Other Developing Countries:					
Khan et al., 2019	Pakistan	3071	29.4	0.82	Residence, wealth index, mother's employment status, consanguineous marriage, sex of the child, mother's education level, child size at birth, mother's nutritional status, mother's height, mother's BMI
Sulaiman et al., 2018	North Sudan	1447	32.7	1.23	Age, Gender
Khaing et al., 2019	Myanmar	4286	18.3	0.59	Child, age, child's gender, preceding birth interval, mother's BMI, father's education, birth weight
Upadhyay & Bhusal. 2017	Nepal	2334	11	0.65	Wealth index, smoking habit, size of child at birth, mother's BMI, mother's height
Sapkota & Gurung 2009	Nepal	150	27	3.62	Socio-economic status, illness within last 1 month, mother's age when child was born
Chowdhury et al., 2019	Bangladesh	7568	36.3	0.55	Sex of child, mother's BMI, food security, religion, region of residence
Mengistu et al., 2013	Hidabu Abote (North Shewa)	820	30.9	1.61	Total under 5 children in the household, kind of foods/fluids as pre-lacteal
Das & Gulshan. 2017	Bangladesh	17,989	33	0.35	Age of child, place of residence, father's education, mother's education, father's occupation, mother's occupation, mother's BMI, wealth index, toilet facility, number of living children and birth order
Akombi et al., 2017	Nigeria	24,529	29	0.29	Geo-political zone, combined place,/mode of delivery, mother's moderation of breastfeeding, preceding birth interval, sex of child, perceived birth size, child had diarrhoea recently, child had fever in last 2 weeks

ii) **Pooled Estimate of Prevalence for Wasting in Under Five Children:** Table 2 similarly showed prevalence (%) of wasting in under 5 children from India & some other Developing Countries. As it can be seen, wasting also differed with geographical regions. In India, prevalence of wasting was highest in Maharashtra (29%) and lowest in Mumbai (9%). In some other Developing Countries, prevalence of wasting was highest in Nepal (29%) and lowest in Myanmar (6.8%).

Fig. 3a showed the *Forest Plot* of wasting for India and some other Developing Countries, giving distribution of prevalence rates in 10 studies and 9 studies respectively. As regards India, highest prevalence estimate of wasting was 29% (95% CI: 26.87, 31.13) and the lowest was 9% (95% CI: 5.88, 12.12). Overall pooled prevalence estimate for wasting was 19.49% (95% CI: 16.24, 22.75), with high heterogeneity of prevalence estimates for wasting amongst 10 studies ($I^2 = 99.52\%$ *and* $p = 0.00$). For some other Developing Countries, highest prevalence estimate for wasting was 29% (95% CI: 27.16, 30.84) and lowest was 6.80% (95% CI: 6.05, 7.55). Overall pooled prevalence estimate for wasting was 16.00% (95% CI: 11.74, 20.64), with high heterogeneity of prevalence estimates of wasting amongst 9 studies ($I^2 = 99.49\%$ *and* $p = 0.00$). Fig. 3b showed evidence of publication bias in above studies on wasting. As can be seen, the *Funnel Plot* doesn't exhibit the expected normality in the estimates of wasting. Furthermore, there are fluctuations in the spread of these prevalence rates which are more on the upper side of the estimates.

iii) **Pooled Estimate of Prevalence for Under-Weight:** Table 3 showed prevalence rates of underweight in under 5 children too differed with geographical regions. Within India, prevalence of underweight was highest in Maharashtra (64%) and lowest in Pune (21.8%). In Developing Countries, it was highest for Bangladesh (36.3%) and lowest for Nepal (11%).

Fig. 4a showed the *Forest Plot* of underweight in children below 5 years of age for India and some other countries, giving distribution of such prevalence rates, based on 11 studies and 9 studies, respectively. For India, highest prevalence estimate of underweight was 58% (95% CI: 55.81, 60.19) and lowest was 21% (95% CI: 17.75, 25.85). Overall pooled prevalence estimate of underweight was 42.08% (95% CI: 34.30, 49.85), with high heterogeneity of these prevalence estimates among 11 studies ($I^2 = 99.92\%$ *and* $p = 0.00$). For some other Developing Countries, the highest pooled

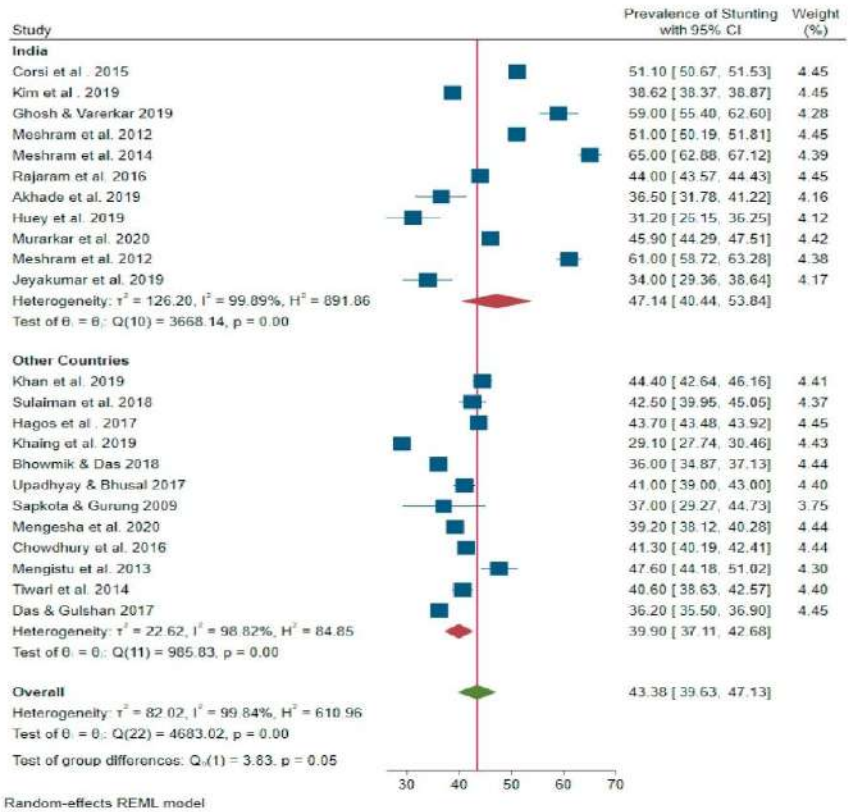

Fig. 2a. Forest Plot of stunting in under 5 children, based on selected studies from India & some other Developing Countries (viz. Pakistan, Bangladesh, North Sudan, Ethiopia, Myanmar, Nepal & Nigeria).

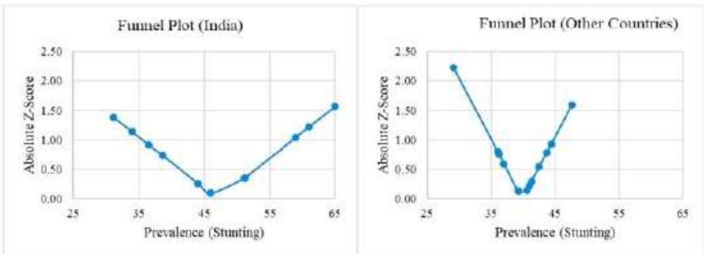

Fig. 2b. Funnel Plot of stunting in under 5 children, based on selected studies from India and some other selected countries (viz. Pakistan, Bangladesh, North Sudan, Ethiopia, Myanmar, Nepal & Nigeria).

prevalence estimates of underweight was 36% (95% CI: 35.22, 37.38) and the lowest was 11% (95% CI: 9.73, 12.27). Overall pooled prevalence estimates of underweight was 27% (95% CI: 22.17, 32.83), with heterogeneity of prevalence estimates among these 9 studies being quite high again ($I^2 = 99.48\%$ *and* $p = 0.00$). Further, the *Funnel Plot* (Fig. 4b showed evidence of publication bias, as it doesn't exhibit the expected normality in the estimates of the underweights. Furthermore, there are fluctuations in the spread of these prevalence estimates, which are more on the upper side.

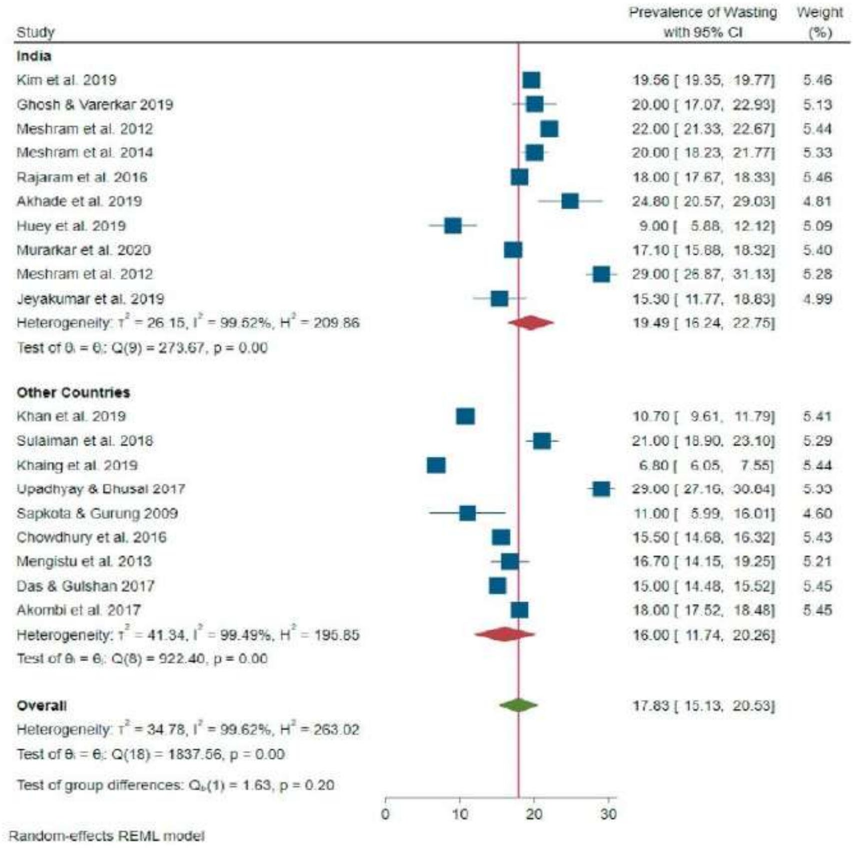

Fig. 3a. Forest Plot of wasting in under 5 children, based on selected studies from India And some other selected countries (viz. Pakistan, Bangladesh, North Sudan, Ethiopia, Myanmar, Nepal & Nigeria).

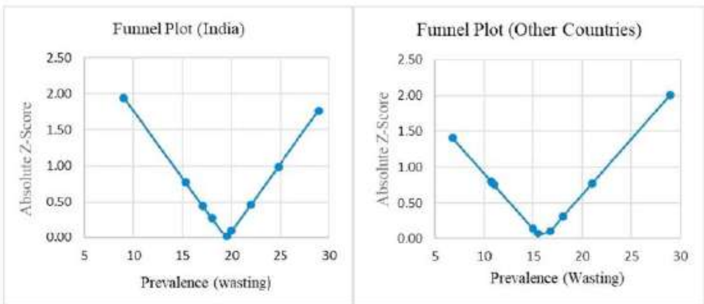

Fig. 3b. Funnel Plot of wasting in under 5 children, based on selected studies from India And some other selected countries (viz. Pakistan, Bangladesh, North Sudan Ethiopia, Myanmar, Nepal &Nigeria).

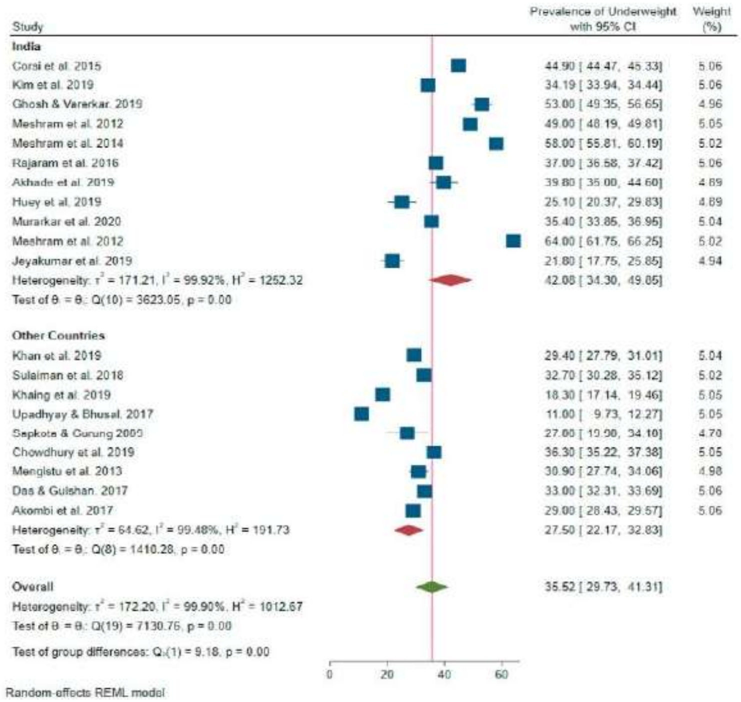

Fig. 4a. Forest Plot of under-weight in under 5 children, based on selected studies from India and some other selected countries (viz. Pakistan, Bangladesh. North Sudan, Ethiopia, Myanmar, Nepal & Nigeria).

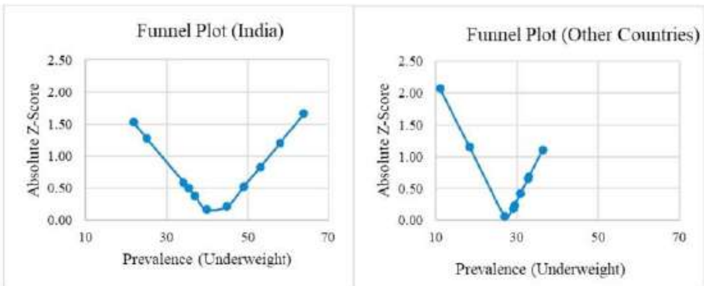

Fig. 4b. Funnel Plot of under-weight in under-5 children, based on selected studies from India and some other selected countries (viz., Pakistan, Bangladesh, North Sudan, Ethiopia, Myanmar, Nepal & Nigeria).

4. Discussion

Child-malnutrition is a serious public health problem in several Developing Countries including India. Under-nutrition is often measured by stunting, wasting and underweight. Stunting measures chronic under-nutrition whereas under-weight is a composite measure of both acute as well as chronic forms of under-nutrition. Wasting is defined as low weight for height. It often indicates recent and severe weight-loss, although it can also persist for a long time. These are most prevalent forms of child under-nutrition amongst children across the globe.

In Developing Countries like India, almost 50% of total deaths among children under 5 are attributed to the under-nutrition. Many studies on this subject have been carried out with varying prevalence rates and determinants by region [1–24]. Hence, to come out with reliable summary estimates, i.e., to arrive at overall accurate estimate of stunting, wasting and underweight, a study was undertaken, using meta-analysis. Out of 190 available studies, published on the subject from India and other Developing Countries in a period of 12 years (2009–2020), as filtered from PubMed and Google data base, only 24 studies met our inclusion and exclusion criteria for final selection of studies, to be used in the meta-analysis.

In our systematic review, a random effect model was considered, based on the assumption that data used for meta-analysis were obtained from randomly selected sample of studies. Nominal heterogeneity observed in these studies was due to variations in the study populations in which studies were carried out. Similarly, our study also used random effect model for meta-analysis, considering the likelihood of significance of heterogeneity amongst studies and tested with Q-test [25–27].

The prevalence of stunting varied with geographical regions. In India, overall pooled prevalence estimate for stunting was 47.1%, with mother's education, age, household wealth, as significant factors in around 50% or more of the reviewed studies [8–13,20–24]. Moreover, prevalence of stunting was variable, highest in Odisha (65%) [10] with age, religion, literacy status of parents and household wealth as significant factors, and lowest in Mumbai (31.2%) [24] with sex, birth weight, haemoglobin, income, maternal height, maternal education as significant determinants. However, for Developing Countries other than India, the pooled prevalence rate for stunting was 39.9%, with age, mother's education, household wealth and mother's BMI as significant factors in 50% or more of the reviewed studies [1–7,14–19]. The prevalence of stunting was quite high in Hidabu Abote District (North Shewa) in Ethiopia (47.6%) with child age, family income and pre-lactation foods/fluids as significant factors [16]. It was lowest for Myanmar (29.1%) with significant factors - child's age, child's gender, preceding birth interval, mother's BMI, parent's education, birth-weight, socio-economic status [5].

Prevalence of wasting in under 5 children within India & some other Developing Countries also differed with geographical regions. In India, overall pooled prevalence estimate for wasting was 19.49%, with age, and household-wealth being the significant factors in around 30% of the reviewed studies [8–13,20–24]. Moreover, prevalence of wasting was highest in Maharashtra (29%) [11] with gender, fever and diarrhoea being the significant determinants. In some other Developing Countries, pooled prevalence estimate for wasting was 16.00%, with mother's BMI as significant factors in around 60% or more of the reviewed studies [1–7,14–19]. Prevalence rate of wasting was highest in Nepal (29%) [14] with size of child at birth, child's sex and mother's BMI as being significant factors. It was lowest in Myanmar (6.8%) [5] with significant factors being child's age, mother's BMI, father's education and socio-demographic status.

Prevalence of underweight in under 5 children too differed from region to region. Within India, the pooled prevalence estimate of underweight was 42.08%, with maternal education as the significant risk factor in around 50% or more of the reviewed studies [8–13,20–24]. Prevalence of underweight was highest in Maharashtra (64%) [11] with gender, mother's education, acute respiratory infections as the significant factors. However, in other Developing Countries, pooled prevalence estimate of underweight was 27%, with mother's BMI as significant risk factor in around 50% or more of the reviewed studies [1–7,14–19]. Prevalence rate of underweight was highest for Bangladesh (36.3%)[1] with significant determinants - child's sex, mother's BMI, food security, religion and region of residence. It was lowest in Nepal (11%) [14] with wealth index, smoking habit, size of child at birth, mother's BMI and mother's height as its significant factors.

5. Conclusions

Our meta-analysis results gave estimates of prevalence of stunting, wasting and underweight for under 5 children in India to be 47.14%, 19.49% and 42.08% respectively as against 39.90%, 16.00% and 27.50% respectively in these children in other Developing Countries. As regards over-all (for under-5 children from all Developing Countries – considered here, taken together), prevalence of these indicators of under-nutrition, these estimates – in the same order, were 43.38%, 17.83% and 35.52% respectively. Further, these estimates – in each case, varied with geographical regions. Also, the Funnel Plots gave evidence of publication bias in each case. Some major factors, found to be significantly associated with under-nutrition included–child's age & gender, birth-weight, family income, maternal education and mothers' BMI, etc. It appears that, to carry out differentials in the estimates of under-nutrition and ways to reduce in under-5 children from Developing Countries, more studies on this subject, are required are required.

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Authors contributions

Pradyuman Verma and Jang Bahadur Prasad contributed to the design of the study, did analysis, interpreted the results and drafted the manuscript of the paper. Also, Pradyuman Verma was involved in gathering published studies on the subject from different sources and then critically reviewing them. In the end, both the authors finalized the manuscript and approved draft of the paper for publication.

Consent to participate (ethics)

The present study is the systematic review of publicly available published studies and hence, question of 'consent to participate' by the individual-subjects does not arise.

Consent to publish (ethics)

Not applicable.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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