ASSOCIATION OF ENVIRONMENTAL EXPOSURES, LIFESTYLE BEHAVIOR AND BMI AMONG 6-12 YEAR OLD CHILDREN IN THREE RURAL CLUSTERS OF HARYANA

THESIS SUBMITTED TO UNIVERSITY OF DELHI
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SUBMITTED BY

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CERTIFICATE

(As required under clause 10 (revised) of ordinance VI-A of the University of Delhi)

The work embodied in this thesis titled **"Association of environmental exposures, lifestyle behavior and BMI among 6-12 year old children in three rural clusters of Haryana"** has been carried out by me under the guidance of Dr. Seema Puri (Supervisor) and Dr. Nikhil Tandon (Co-Supervisor).

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This work is dedicated to my teacher "guru" who not only inculcated passion for research but has made me a fine human being

"Prof. Narendra Kumar Arora"

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ABSTRACT

The economic development of the country has resulted in epidemiological transition, demographic transition and thus dietary transition. On the other hand, the concurrent increasing prevalence of underweight and overweight/obesity among children with changing diet and physical activity patterns has necessitated the need of a unifying/multi-level approach to understand the determinants of the problem. Thus, the present research study was conducted to determine the associations between lifestyle behavior, immediate environmental exposures and eating pattern phenotypes with the BMI of children (6-12 year old) (n=612) residing in three rural clusters of Palwal district, Haryana. The three rural clusters selected for the study were located at the three different locations according to their access to highways in the surveillance site. These clusters were found to be significantly different from each other in terms of their socio-demographic profile, socio-economic profile, living conditions, environmental hygiene and health seeking behavior. Though these clusters were different, the quality of living conditions and environmental hygiene was poor across three clusters. The children (6-12 year old; n=612) part of this study had higher intakes of dietary energy (2135kcal; 95%CI: 2051-2244), a high sugar intake (56.7g 95%CI: 50.5-62.7); one-fifth share of the energy being derived from unhealthy foods, engagement in high levels of physical activity (2569.7 met minutes; 95% CI: 2481.9-2638.6) and significant differences in the BAS scores and eating behavior. However, despite having a high energy intake, 22.5 per cent of the recruited children were thin/severe thin as per their BMI-for-age categories. The children residing in three rural clusters had significantly different home environment, built environment, community food environment and school environment. The determinants of the BMI among children were determined at three-tier hierarchy including individual, household and community level determinants. The significant determinants ($p<0.005$) of thinness/severe thinness among children in rural areas individual level includes age more than 10 years, low fat intake and its contribution to total energy, higher contribution of carbohydrates to total energy, active mode of transportation to school, higher BAS score. The significant determinants ($p<0.05$) of thinness/severe thinness at household level include maternal education less than 5 years, poor socio-economic class of the household, open field as mode of defecation, lower per capita availability of cereals, pulses, milk and milk products, fats and oils and sweets and

confectionaries in the household, lower per capita total food expenditure in the household, higher percentage total food expenditure on sugars and lower per capita total food expenditure on sweets and confectionaries. However, at the community level only cluster of residence and type of school varied among children in two groups according to their BMI and there were no significant differences in the built neighborhood environment, community food environment and indicators of school environment. The significant determinants of the BMI among children as per the multi-variate logistic regression analysis were age (>10years) (OR: 2.1; 95% CI: 1.0-4.4), the interaction between minority category and poor socio-economic class of the household (OR: 4.4; 95% CI: 1.6-12.1), availability of sweets (OR: 0.9; 95% CI: 0.8-0.99) and cereals (OR: 0.9; 95% CI: 0.8-1.0) in the household and poor street condition (proxy indicator of the hygiene and cleanliness in the neighborhood) (OR: 0.3; 95% CI: 0.1-1.1). All the factors like significantly contributed in explaining the variability governing the risk of getting thin/severe thin among children in rural area (p-value: 0.0001; Adjusted R^2: 0.156). Overall, at the cluster level the cluster with a high and upper middle class socio-economic status had lowest prevalence of undernutrition and highest prevalence of overweight and obesity with the lowest proportion of minority population and low percentage contribution of unhealthy foods with low retail density. However, in the poorest cluster had a highest proportion of minority population, highest prevalence of undernutrition and lowest overweight and obesity, highest contribution of unhealthy foods to the total energy and highest retail density. Thus, all these factors interplay with each other and increases the risk of being thin/severe thin in a rural community. To conclude these rural areas in Haryana are undergoing developmental transition with increasing population density; congested living spaces; increased retail spaces; and market food availability leading to erosion of traditional lifestyles and dietaries. In this area, the total food and unhealthy food intake of children of children has increased considerably without having any influence on the nutritional status of children with the changing lifestyles. Therefore, it is required for a further research study on studying the gut related factors, which are very critical in defining the nutritional status of children despite of having a high calorie diet.

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LIST OF ABBREVIATIONS

BAS	Behavioral Activation Scale
BEAT	Built Environment Assessment Tool
BIS	Behavioral Inhibition Scale
BMI	Body Mass Index
BPL	Below Poverty Line
CDC	Centre For Disease Control
CI	Confidence Interval
CMDM	Cooked Mid Day Meal
CSHQ	Child Sleep Health Questionnaire
DBP	Diastolic Blood Pressure
DDESS	Demographic Development and Environment Surveillance Site
DLHS	District Level Health Survey
FPRD	Food Purchase Record Diary
GIS	Geographic Information System
HAZ	Height-for-age z scores
HC	Hip Circumference
HFI	Household Food Inventory
IDI	In-Depth Interview
INR	Indian Rupees
IQR	Inter-Quartile Range
LPG	Liquid Petroleum Gas
MDM	Mid Day Meal
MET	Metabolic Equivalents
MP	Kundli-Manesar-Palwal
MUAC	Mid Upper Arm Circumference
MVPA	Moderate-To-Vigorous Physical Activity
NFHS	National Family Health Survey
NH-2	National Highway-2
NIN	National Institute Of Nutrition
NNMB	National Nutrition Monitoring Bureau
NSSO	National Sample Survey Office
OBC	Other Backward Class

OR	Odds Ratio
PAL	Physical Activity Level
PDS	Public Distribution System
RDA	Recommended Dietary Allowance
RDI	Recommended Dietary Intake
SBP	Systolic Blood Pressure
SC	Scheduled Caste
SES	Socio-Economic Status
SHAPES	School Health Action Planning Evaluation Survey
SSB	Sugar Sweetened Beverage
ST	Scheduled Tribe
TBSP	Table Spoon
TSP	Tea Spoon
UID	Unique Identification Number
UNICEF	United Nations International Children's Emergency Fund
WAZ	Weight-for-age z scores
WC	Waist Circumference
WHO	World Health Organization

Chapter 1
Introduction

CHAPTER 1
INTRODUCTION

In India, food is an integral part of family and social life, and is deeply embedded in the culture. The rapid economic growth that the country has witnessed in the last decade has led to changes in the life style of families in both rural and urban areas. India's booming economy eroded traditional food patterns, with increased exposure to foods from other cultures. It has also promoted growth of fast food industry providing convenient and inexpensive meals, which contain more fats, salts, and sugars (Vaz et al, 2005; Popkin, 2002; Shetty 2002). It is evident from the given literature that these changes in the lifestyle are bi-products of the developmental process taking in an area (Chan et al, 2010).

The epidemiological, demographic and nutrition transition in conjunction with the sedentary lifestyles have contributed to obesity and diet-related non-communicable diseases (DR-NCD) especially among urban children. Despite an increasing prevalence of overweight/obesity among children, India is also home to around one-third of undernourish children in the country (UNICEF, 2015). The national prevalence of stunting, underweight and wasting is 38.7 per cent, 29.4 per cent and 15.1 per cent among under-five children (UNICEF, 2015). Hence the country is facing a dual burden of malnutrition, both undernutrition and overnutrition.

Underweight and obesity are both among the top ten leading risk factors for global burden of disease (WHO, 2002**.** Despite an overall decline in prevalence of stunting, child malnutrition remains a major public health problem in most developing countries. Most of the nutrition surveys in developing countries did not report overweight prevalence as the focus was on the lower end of nutritional distribution. Paradoxical coexistence of obesity with under-nutrition is observed in up to 60 per cent of the households in some of the countries in Asia, Africa & Latin America (Doak et al, 2005)**.** Children in low and middle income countries on the one hand are more vulnerable to inadequate pre-natal, infant and young child nutrition and on the contrary they are more exposed to cheaper high-fat, high-sugar, high-salt, energy dense, micronutrient poor foods (WHO, 2011). The consumption of these foods might have an impact on increasing the body fat content of the individual and thus body fat (Gregori et al, 2014; Fraser et al, 2012).

The ***burden of chronic diseases*** is rapidly increasing worldwide, contributing to 46 per cent of the global burden of the disease and cause over 60 per cent of the deaths all around the world (James, 2010; Monteiro, 2010; WHO, 2002).Almost half of the total chronic disease deaths are attributable to cardiovascular diseases; diabetes and obesity, which are one of the major risk factors of chronic diseases. These are also showing worrying trends, not only because they already affect a large proportion of the population, but also because they have started to appear earlier in life. Therefore, the diseases termed as "diseases of affluence" is a misnomer, as they emerge both in poorer countries and in the poorer population groups in richer countries. This shift in the pattern of disease is taking place at an accelerating rate; furthermore, it is occurring at a faster rate in developing countries than it did in the industrialized regions of the world half a century ago (Popkin, 2012).

International Diabetes Foundation projections suggest that about 84 million Indians are expected to suffer from diabetes by 2030 (IDF, 2009) and till date 62 million individuals have been diagnosed with the disease. This has resulted in greater levels of morbidity and mortality due to an early age-onset of the disease in the population (Kaveeshwar and Cornwall, 2014).On a global basis, 60 per cent of the burden of chronic diseases will occur in developing countries. Indeed, cardiovascular diseases are even now more numerous in India and China than in all the economically developed countries in the world put together (WHO, 2002). Death due to cardiovascular diseases among Indians is expected to rise from 29 per cent in 2005 to 36 per cent by 2030 (Mathers and Loncar, 2005). As for overweight and obesity, not only has the current prevalence already reached unprecedented levels, but the rate at which it is annually increasing in most developing regions is considerable (Popkin, 2002). The public health implications of this phenomenon are staggering, and are already becoming apparent.

The high prevalence of undernutrition among children has nutritional outcomes in terms of acute/chronic undernutrition or micronutrient deficiencies, percentage body fat, school an academic performance by hindering the mechanism of cognitive development, unemployment, absenteeism or low performance at job, economic outcomes (decreased school attendance, labor productivity, enhanced healthcare expenditure and tax deficit for the government) (Bagriansky et al, 2014; Bagriansky and Voladet, 2013; Laillou et al, 2012; Victora et al, 2008; Data et al, 2004; Wang et al, 2002).

India heads the list of countries with largest affected population. In India***: nutrition transition*** estimated between 1973 and 2004 has highlighted 7 per cent decrease in energy consumed from carbohydrates and 6 per cent increase in energy consumed from fats (Misra et al, 2011). These unprecedented changes in lifestyles, including less physical activity and food habits could be attributed to the after effects of urbanization, mechanization and globalization, which have led to escalating rates of obesity, and other cardio-metabolic diseases. Closely intertwined are issues of epidemiological transition and changes in traditional dietary patterns. Presently non-communicable diseases are the top cause of mortality (55%) in both urban and rural India. People of all age groups in all regions are at higher risk however relative risk increases with patient's habit, socio economy and their built and spatial environments. The factors which have led to the nutrition transition in the country and across the world are the result of technological changes brought as a result of globalization (Popkin et al, 2012).

In India, the Green Revolution has yielded dramatic changes to the production of staple food items in India followed by the White Revolution which brought about policy changes to achieve self sufficiency in milk production (FAO, 2006). Along with the rising affluence brought about by globalization, industrialization and urbanization, food habits are changing and modern food items (processed and non-processed) are penetrating in to remote India as well. Thus, the local or rural food systems are found to be intricately entwined with the urban, national and international supply chain systems. According to World Health Organization (WHO, 2008) and the World Economic Forum, India will incur an accumulated loss of $237 billion by 2015 due to unhealthy lifestyle and faulty diet (Sinha, 2009).

The ***dietary changes*** as a result of transition are both quantitative and qualitative and include shifts towards higher energy density with a greater role for fat and added sugar in foods, greater saturated fat intake mostly from animal sources, reduced intakes of complex carbohydrates and fiber, and reduced fruit and vegetable intakes (Popkin, 2012). This shift away from traditional, monotonous habitual intakes now characterized by increasing diversification of diets, while promoting better nutritional outcomes also has downsides which need urgent attention as they are also occurring faster now than in the past.

Diseases and ill health attached to the nutritional status of the child in terms of under and over nutrition and their chronic disease consequences result for a large part from the misalignment of our biological predisposition toward food, in particular these high in sugar and fat, with the every-day modern environment we are progressively creating worldwide, with ubiquitous high-caloric fat and sweet food and increasing inactivity (Kahneman et al, 2010; Polivy et al, 2010; Thibault et al, 2010).The urban-rural differences in energy consumption (kcal) have started diluting in the last decade. The share of cereals to the total energy intake though increased with the increase in socio-economic status of the households (NSSO, 2010). The intake of fats and oils have increased by 3 percentage points among both rural and urban areas in the last decade with an approximate consumption of 53 grams per day in urban areas and 43 grams in rural areas.

In India, per capita consumption of sugar increased from 22 grams/day in 2000 to 55.3 grams/day in 2010 while per capita consumption of table salt ranges between 9 to 12 grams/day (Balasaheb, 2014). Per capita consumption of total fat was 21.2 grams/day in 2000 and increased to 54 grams/day in 2010. Similar trend was observed in per capita edible oil consumption which increased from 27.3 grams/day to 37 grams/day. At the national level, per capita consumption of sugar is now approximately 10 spoons, adding up to 18 kg/year (ICAR, 2011). Population studies by the ICMR in 1988 in 13 Indian states reported salt consumption at 13.8 grams/day.

Recent estimates by ICMR-INDIAB study reports 7.6 ± 3.3 grams/day consumption in urban areas, significantly higher than that in rural areas (6.8 ± 3.5 grams/day). Salt consumption reported in the 66th Round of NSS in 2010 was 8.9 grams per person per day which is above the National Institute of Nutrition (NIN) recommended RDI

(Recommended Dietary Intake) of 5 g per person per day (Mohan and Prabhakaran, 2013). Chennai Urban Rural Epidemiology Study (CURES) also reported mean dietary salt intake as 8.5 grams/day; while higher salt intake was associated with older age and higher income (Radhika et al, 2007). However these estimations are on dietary recalls on household utilization of salt and does not account for the added salt in the processed foods like pickles, bread products, savoury snacks, ketchup, mayonnaise, other sauces and breakfast cereals. In conjunction to the increased consumption of the salt at the household level for cooking food there has been a rising annual production of edible salt, from 2.8 (million tons) in 1992-93 to 6.2 (million tons) in 2013.

The consumption of sugar-sweetened beverages and packaged fruit juices has contributed to the market at a compound annual growth rate (CAGR) of 13 per cent since 2009 and to the per-capita daily caloric intake of among children and adults (Bhaskar, 2014). In US this has gone up from 242 kcal per person per day in 1988-1994 to 270 kcal per person per day in 1999-2004 (Wang et al, 2008). The demand of these food items (processed foods, sugar sweetened beverages and savory snacks) at household level is governed by the ***disposable incomes of Indian middle class*** (Pingali and Khwaja, 2004). The growing heterogeneous consumption pattern of middle class drives the availability of consumer goods in the market. Brand experts from industries recognize that purchasing power in families is moving into the hands of women (Sharma and Singh, 2011). Around 26 per cent of working forces in rural areas and 13.8 per cent of urban workers are women (Bhalla and Kaur, 2011). A recent study on under nutrition, by The INCLEN Trust International, highlighted that women in both urban and rural India are spending less time for cooking. This along with the shift in purchasing power and disposable family incomes could be coined to explain the rising demand in packet foods and semi cooked food materials. ***Genetic and intra-uterine growth*** imbalance also contributes to the occurrence of overweight and obesity in children (Misra et al, 2009; Misra and Khurana, 2008).

This ***disparity in the motivated choice behavior*** of an individual, such as food, which is driven by both human physiology (dopamine-driven reward, reinforcement, and cue-induced processes and impulses shaped by human evolution) and executive control functions instigated by the prevailing modern environment, has an impact on the eating behavior and the Body Mass Index (BMI). The adult with reward-seeking phenotype (Guerrieri et al, 2008; Nederkoorn et al, 2006), are susceptible to high density of fast food (Paquet et al, 2010) as compared to the 'restrained eater' (individuals who typically rely on cognitive control food intake) may have unanticipated responses to well-intended societal interventions by responding to smaller food packages but in fact eating more (Scott et al, 2008).

Additionally, changing pattern of occupations and associated mobility, infrastructure development and media have also influenced ***physical activity*** opportunities. Globally 31 per cent of adults aged 15 and above (men 28% and women 34 %) and 64 per cent of children (10-18 years) are insufficiently active (WHO, 2008; WHO, 2007). The prevalence of insufficient physical activity rose according to the level of income. High income countries had more than double the prevalence compared to low income countries for both men and women, with 41 per cent of men and 48 per cent of women being insufficiently physically active in high income countries as compared to 18 per cent of men and 21 per cent of women in low income countries. Nearly every second woman in high income countries was insufficiently physically active. The increased automation of work and life has created opportunities for insufficient physical activity.

The rapid socio economic progress in Asian countries like India is resulting in ***urbanization*** of the country with a rural urban transition. The proportion of urban population has increased from 28.5 per cent in 2001 to 31.2 per cent in 2011 (Census, 2011). Over 70 per cent of the affluent urban Indian consumers live in the 10 most populated and cosmopolitan cities in India. But this transition is not taking place in isolation and is emanating the shift in traditional whole foods to modern processed diets, abundant food supply with massive marketing campaigns, reduced physical activity, use of motorized transport, expansion of international trade and economic integration (Guldan, 2010). All these changes in our environment surrounding us act as a barrier to maintain a healthy weight. With the rapid growth of Indian cities there is an increased demand for land and travel in urban area, thus putting enormous pressure on transport and other kinds of public infrastructure (Das et al, 2010). The walking share of all travel has fallen from 37 per cent to 28 per cent in cities of over 5 million inhabitants. There is steep in cycling share of physical activity from 26 per cent to 9 per cent and use of public transport has increased up to 63 per cent (Singh, 2005).

These development-associated life style changes are gradually affecting the wellbeing of the populations. Fuelled by country's rapid economic growth, modernization and urbanization, India is witnessing unprecedented increase in childhood and adult obesity, continued increased prevalence of undernutrition and its subsequent chronic disease consequences, a growing problem driven in part by changed consumption patterns associated with caloric imbalance (WHO, 2003).

1.1. Rationale

Depending on the epidemiologic transition of the country, there has been a marked increase in the prevalence of the chronic diseases contributing to the global burden of disease and disability. With this, there is a rapid growth in the levels of obesity, high rates of underweight and stunting among children are leading to a dual burden of malnutrition. With the increase in income, the proportionate intake of fats, saturated fats and sugars has increased. Though the levels of physical inactivity is increasing but more than this there is a larger shift towards the less physically demanding work in occupations like agriculture, industry and services. Economic growth, modernization, urbanization and changing market structure are the societal and environmental forces responsible for the epidemic.

There is increase in passive over-consumption due to several changes in consumer behavior; like increase in food and beverage portion sizes, increased consumption of sweetened beverages, food advertising on TV including the targeted marketing of high-energy, low nutrient dense foods (Tirodkar and Jain, 2003). There is proliferation of fast food outlets, limited availability of healthy foods, increasing consumer dependence on food eaten or purchased away from home along with price difference between the energy dense and healthy foods (Morland et al, 2002; French et al, 2001). There is need to move from macro-societal level, through microenvironments, to individual behavior for a successful understanding of the causal associations and possible interventions. Thus, with the excess supply of energy dense foods, changes in the pattern of maternal occupation from farming to daily wage earning, reduced occupational physical activity, increased population density, poor household characteristics features in terms of sanitation and water supply, increase in national income makes a strong case for the country to be in the state of rapid transition at all levels (demographic, epidemiological and nutrition).

The existing literature has majorly focused on unraveling the determinants and mediators of obesity-genetic, metabolic, psychological, behavioral and demographic. This has enabled us to understand the determinants and etiology behind the cause but is not helped us in understanding the solutions. With this reason there is a failure in the implementation of national strategic plans developed by most of the countries addressing obesity in relation to nutrition, healthy eating, physical activity and non-communicable diseases (Swinburn and Silva-Sanigorski, 2010). Thus, there is an urgency to address the socio-cultural moderators of obesogenic behavior and a holistic approach to understand the etiology behind the cause, which has been barely addressed in the current research paradigm. It is now well understood that challenges of addressing the determinants of nutritional status of children are complex because many of the environmental challenges faced by human biology lie in the social and economic domains (agriculture, agri-food, business, media, transportation, etc.), and are from outside the traditional purview of health and healthcare (Das et al, 2010; Pingali, 2010; Tontisirin et al, 2010).

With this backdrop the proposed research is planned to study the relationship of the environmental level exposures i.e., family/household level, neighborhood and community level on the nutritional status of children in rural Haryana. The study is a part of larger research program ***"Foundational work for a Brain-to-Society diagnostics for prevention of childhood obesity and its chronic diseases consequences"*** funded by ICMR under the ICMR-CIHR collaboration on childhood obesity 2009-2010. The project is a joint venture of The INCLEN Trust International lead by Prof. Narendra Kumar Arora and McGill World Platform for health and economic convergence led by Prof. Laurette Dube. For the study purpose INCLEN has set up a demographic surveillance site called 'SOMAARTH' in the Palwal district of Haryana in India. The district has 48 villages and is bounded by NH2 (National Highway) on east, Palwal Mewat state highway on the northern side and Nuh-Hodal state highway on south side.

1.2. Hypothesis

The lifestyle behaviour and environmental factors [family/household level, physical activity and eating environment in schools, neighborhood and built environment] in rural area are associated with the BMI of 6-12 year old children are associated with the BMI of children 6-12 years old in a rural area undergoing different stages of development.

With this hypothesis the study proposed study is planned with the following objectives.

1.3. Objectives

1. To determine the BMI in a group of 6-12 year old children in three rural clusters of Haryana.
2. To assess the diet and physical activity profile of the same 6-12 year old rural children.
3. To evaluate the eating pattern phenotypes of the same 6-12 year old rural children.
4. To determine the immediate environmental level factors at family/household level, school level, neighborhood and built environment of the 6-12 year old rural children.
5. To determine the association of environmental level factors and lifestyle behavior with BMI of 6-12 year old children residing in the three rural clusters.

Chapter 2
Review of Literature

CHAPTER 2
REVIEW OF LITERATURE

2.1. Introduction

In the last two decades, India has witnessed rapid economic development with increasing GDP, along with a concurrent demographic transition not only increasing the working age population but also the elderly population. With urbanization changes in diets and lifestyle behavior, the non-communicable diseases such as obesity, diabetes and cardiovascular diseases have emerged as important health concerns. However, the conditions of undernutrition, stunting, wasting and underweight still persist in the country. This process has led to the presence of a dual burden of malnutrition (under nutrition and over nutrition) in the country.

The process of nutrition transition is driven by the interplay between various factors playing at national level, household level and individual level. The national level determinants include GDP of the country, liberalization and globalization of the country, urbanization and high population density of the area. The household determinants include shift in occupation from agrarian economy to the service sector, socio-economic status of the household, increased share of income by women in the total household income, ownership of assets which facilitates reduction in physical activity, changes in the household food processing technology and cooking practices. Lastly, the individual level determinants include increase in total energy intake and percent contribution of fats and oils, increased portion sizes, low dietary diversity of food consumed, increased intake of sugars and sugar sweetened beverages and reduced levels of physical activity (Bishwajit et al, 2014; Popkin 2014; Martinez et al, 2014; Popkin et al, 2012; Popkin 2011).

The nutrition transition was first documented by Popkin (1998) using the data from the Chinese Health and Nutrition Survey (CHNS) with a longitudinal study design. The data from the survey reiterated the conceptual framework on nutrition transition and identified various socio-economic and demographic shifts at the national survey which had brought about several alterations in the lifestyle of individuals (diet and physical activity). This shift in the lifestyle resulted in a high prevalence of obesity and the population was projected at a higher risk of non-communicable diseases (Zhang et al, 2014). This shift has been rapid in the developing countries that still have not got over with the phase of undernutrition.

In India, at the national level, various secondary analysis and ecological studies have been done to assess the transition in the country. The national surveys (NSSO, National Sample Survey Organization) were used as the secondary data sources in the secondary analysis. In the past three decades, there has been a shift in the dietary patterns of the Indian population from low cost cereals and its products towards high cost foods such as fish, meat and egg. This has increased the cost, reduced the calories and diversified the variety of the food basket of Indian households. There are variations in the dietary patterns among different socio-economic groups and between rural and urban disparity across the country. The increase in the per capita income of the household has resulted in an increased expenditure on food items. An increase of 10 per cent in food expenditure has an association with increase in calorie intake and cost of calories by 5 per cent (Gaiha et al, 2012; Deaton and Dreze 2009). However, the process of dietary transition in the country has been sluggish and protracted in the last decade (2004-09) as compared to the earlier decades (1993-2004). But still being slow paced, this process has been faster in rural poor households as compared to rural non poor households and urban households (Gaiha et al, 2013).

It has been well documented that the various factors which are involved in the process of nutrition transition act in the same manner across different age groups resulting in a nutritional outcome (Popkin et al, 2012). However, there has been an argument made that these differences in the dietary behaviour and shifts from locally grown traditional foods to energy-dense and nutrient deficient foods are different between and within groups (Hook et al, 2013; Hawkes et al, 2006).

2.2. Dual Burden: "Co-existence of Under and Over Nutrition"

The paradoxical coexistence of under- and over-nutrition within a population is referred to as the double burden of disease (Doak et al, 2005) which is now being faced by many low and middle income countries (WHO, 2013) and has been identified as an determinant of society undergoing transition. Dual burden can be defined as the presence of over nutrition and under nutrition among a population group within the same community or the prevalence of over nutrition and under nutrition among the members of the same household (Sunguya et al, 2014; Hook et al, 2013). At present these countries are dealing with the problems of infectious diseases (Chopra, 2004), and also experiencing a rapid rise in non-communicable disease risk factors such as obesity and overweight (WHO, 2013). The prevalence of dual burden in a country is related to the stage of nutrition transition and socio-economic status of the country (Tzioumis and Adair 2015).

Over nutrition and under nutrition are two extremes of the nutritional status spectrum among children where the causes of occurrence are different for both. However, they both seem to co-exist in many societies. According to Ford and Mokdad (2008), a society that is undergoing transition provides the required stimulus for the dual burden of disease among children. These relationships were studied using ethnographic studies in a transitional society of Hong Kong. They showed that both micro-level causes at the individual (diet and physical activity) and macro level factors at the societal level (availability of energy-dense foods, structured built environment, media and advertising) when intertwine with each other influences the nutritional status of children (Chan et al, 2008).

Underweight and obesity are both among the top ten leading risk factors for global burden of disease (WHO, 2002)**.** Despite an overall decline in prevalence of stunting, child malnutrition remains a major public health problem in most developing countries. Most of the nutrition surveys in developing countries did not report overweight prevalence as the focus was on the lower end of nutritional distribution. Paradoxical coexistence of obesity with under-nutrition is observed in up to 60 per cent of the households in some of the countries in Asia, Africa and Latin America (Doak et al, 2005). Children in low and middle income countries on the one hand are more vulnerable to inadequate pre-natal, infant and young child nutrition and on the contrary they are more exposed to cheaper high-fat, high-sugar, high-salt, energy dense, micronutrient poor foods (WHO, 2013). The consumption of these foods might have an impact on increasing the body fat content of the individual and thus body fat (Gregori et al, 2014; Fraser et al, 2012).

The term thrifty phenotype was given by Hales and Barker to describe the disadapted metabolic state arising as a consequence of a fetus that has been undernourished and, hence, forced to adopt a series of survival strategies appropriate to its frugal early nutrient supply but maladaptive if nutritional conditions improve later in life (Hales et al, 2001). The populations in the developing countries which are undergoing rapid economic and nutritional transition are more predisposed to developing diseases of affluence (Fall, 2001). Though very scant evidence is available that it contributes to the development of obesity but robust evidence is available to show that it increases the risk of chronic diseases in individuals who gain weight (Barker et al, 2005; Prentice et al, 2005; Bhargava et al, 2004; Yajnik et al, 2003). Apart from genetic and nutritional programming in fetal life, a range of factors like maternal nutrition, environmental factors and patterns of early life growth influences the development of NCDs and evolution of diabetes. The low-income group of the country comprises of about one-third of the low birth weight neonates born in India (Barker et al, 2005; Yajnik et al, 2003).

2.2.1. Epidemiology of Dual Burden

2.2.1.1. Global Prevalence of Overnutrition and Undernutrition

The global prevalence of overweight and obesity among children has risen to 12.9 per cent for boys and 13.4 per cent among girls in the span of three decades (1980-2013) (Ng et al, 2014). There is a gradual increase in the proportion of children with overweight and obesity which has increased from 4.2 per cent (3.2 to 5.2) in 1990 to 6.7 per cent (5.6 to 7.7) in 2010; with projected figures to cross 9.1 per cent in 2020 if the trends continued (Onis et al, 2010). But the major differences in the dietary patterns and physical inactivity in the last decade have resulted in a cumulative increase in the global burden. The burden of childhood obesity differs by gender in developed and developing countries.

In developed countries, the burden of childhood obesity and overweight is higher among boys as compared to girls (24 per cent vs. 23 per cent), while those in developing countries the trends are vice-a-versa i.e., 13 per cent of boys and 13.4 per cent of girls are overweight and obese (Ng et al, 2014). In affluent countries like United States, around 32 per cent of children aged 2 to 19 years were overweight; a dramatic increase from 5.5 per cent in 1990 to 16.3 per cent in 2010 (Ogden et al, 2012). However, rise in obesity was more among children in the age group 6 to 11 years, from 7.5 per cent to 19.6 per cent, and in adolescent age group 12 to 19 years, from 5 to 18 per cent (Karnik and Kanekar, 2012). In some countries like Mexico, Brazil and Argentina the prevalence of overweight and obesity was as high as 42 per cent, 22 per cent and 19 per cent respectively. For the developing world, similar rising trends were reported for prevalence of childhood obesity (5 to 19 years) (Gupta et al, 2012).

Nutritional status of children is measured as **under nutrition** or **over nutrition**. The indicators used to assess under nutrition include stunting, underweight, wasting and thinness and over nutrition include overweight/obesity (WHO 2010).

Stunting is defined as the height-for-age of children below -2 standard deviations of the median growth reference standards. The genesis of stunting begins within first two years of life and persists till later childhood and adulthood indicating the chronic under nutrition with long-term nutritional deprivation (WHO 2010).

Underweight is defined as weight-for-age of children below -2 standard deviation of the median growth reference standard, indicative of the acute and chronic under nutrition. Underweight children are at high risk of mortality as compared to stunted and wasted children (WHO 2010).

Wasting is defined as weight-for-height of children below -2 standard deviation of the growth reference standard indicative of acute under nutrition. This is a consequence of insufficient food intake or high incidence of infectious diseases (WHO 2010).

Body Mass Index (BMI) [body weight in kg/(height in meter) ^{2}] is the most widely used measure of overweight and obesity across all ages. BMI is used to measure thinness and overweight/obesity in the population (WHO 2010).

Thinness is defined as BMI-for-age of children below -2 standard deviation of the growth reference standard (WHO 2010).

Overweight/obesity is defined as more than 2 standard deviation of the adult

The prevalence of stunting as an indicator among children is of relative importance as compared to underweight (weight-for-age) and wasting (weight-for-height) due to its prevalence globally (WHO, 2010). The global prevalence of childhood stunting among under 5 children was 26.7 per cent (171 million children) in 2010 and is expected to reduce to 21.8 per cent (142 million children) by 2020 (Onis et al, 2012).

These prevalence estimates are based on the growth standards given by WHO (2010). The prevalence of stunting from developing world contributes to 97 per cent of the total stunting prevalence (167 million children). The attained height during adulthood is strongly determined by growth failure during childhood in terms of low height-for-age as evident from the COHORTS (Consortium on Health-Oriented Research in Transitional Societies) study (Stein et al, 2010). Manyanga et al (2014) conducted a cross-sectional survey: Global School-based Student Health Survey (GHS) in seven countries of the Africa region to understand the risk factors behind the dual burden of under and over nutrition among school going adolescents. The age and sex adjusted prevalence of overweight/obesity and underweight was 17.3 per cent and 22.2 per cent respectively among African adolescents. There were no significant associations of the risk factors studies with the weight status of the adolescents.

2.2.1.2. National Prevalence of Overnutrition and Undernutrition

In India, the secular trends show a rising prevalence of childhood obesity – about 2 fold increasing prevalence than that reported 2 decades earlier (Khadilkar et al, 2011; Marwaha et al, 2011). At country level, the rising trends for childhood obesity have been reported in a systematic review (Gupta et al, 2012) and meta-analysis (Hoque et al, 2014). The reported prevalence of childhood overweight and obesity among 5-19 years ranges between 6.1-25.2 per cent and 3.6-11.7 per cent respectively (Gupta et al, 2012). Another meta-analysis from India (n=67,919) has reported pooled prevalence of overweight and obesity as 12.64 per cent and 3.39 per cent in the age group of 2 – 19 years (Midha et al, 2012).

Majority of the prevalence based research studies have been conducted in urban areas resulting in pooled estimate prevalence of 23 per cent (95% CI: 22-24%) to 36 per cent

(95% CI: 34-37%) among 10-18 years of children (Hoque et al, 2014). On the contrary the prevalence of overweight and obesity is on the rise in rural landscape of the country, though very few research studies contribute to the available statistics. The pooled estimate prevalence of childhood obesity is 2 per cent (95% CI: 2-3 %) to 6 per cent (95% CI: 6-7%) among rural children. In the Northern region of India, a three times higher prevalence of overweight was observed among children in high income group schools (15.3%) as compared to middle income group schools (6.5%) and low income group school (2.7%). Prevalence of obesity in high income group schools was 6.8 per cent while that in middle income group schools was 0.6 per cent and low income group schools was 0.1 per cent (Kaur et al, 2008).

However, the research study also showed that there was four times higher consumption of energy dense fast foods among children studying in high income schools (12%) as compared to those studying in middle income schools (9.8%) and low income schools (7.2%). Thus this study reiterates the association of childhood obesity with socio-economic status of families. Misra et al (2011) conducted a multi-centric study in five cities of country covering 38,296 children in the age group of 8 to 18 years. The study used WHOs criteria for classifying overweight and obesity and showed that the overall prevalence of overweight and obesity was 18.5 and 5.3 per cent respectively. Risk factors for obesity in children include high birth weight, low birth weight, parental and maternal obesity, maternal diabetes, urbanization, sedentary lifestyle, increased fast food/fried food consumption, decreased duration of sleep and increased time spent on TV (Kuriyan et al, 2007) and other electronic items. The recently conducted systematic review reported that the combined prevalence of obesity and overweight have shown increasing secular trend (Ranjani et al, 2016).

The national prevalence of stunting, underweight and wasting is 38.7 per cent, 29.4 per cent and 15.1 per cent among under-five children (UNICEF, 2015).The incidence of stunting among Indian children was found to be highest (22%) and lowest rates of recovery from stunting during pre-school years (30%) as compared to other children in low and middle income countries (Ethiopia, Peru, Vietnam) as studied as a part of Young Lives longitudinal cohort (Lundeen et al, 2013). The prevalence of stunting was found to be 40 per cent higher among boys residing in households with poor socio-economic status as compared to girls as reported in a meta-analysis conducted by Wamami et al (2007). The meta-analysis included the data from 16 demographic and health surveys data from Sub-Saharan African region.

The prevalence of wasting, underweight and stunting was reported as 23.3 per cent, 45.4 per cent and 57.4 per cent respectively among 3-9 years of children residing in Bhubaneswar, India (Panigrahi and Das, 2014). The prevalence of underweight, wasting and stunting reported among 5-15 year old children residing in an urban slum of Bareilly district was 38.4 per cent, 33.3 per cent and 9.9 per cent respectively (Srivastava et al, 2012).

2.2.2. Implication of Overnutrition and Undernutrition

The undernourish child is subjected to poor cognitive development and skills. The explanatory factors behind the mechanism include direct structural damage to brain and impairing motor development during infancy (Mani et al, 2013). The deprived environment with absence of opportunities exaggerates the poor cognition among undernourish children. These further result in the poor academic performance of the child (Dewey and Begum, 2011). Studies from low and middle income countries have shown that there are long-term deficits in the fat mass of a child if has impaired fetal nutrition (Rogers, 2003). Childhood stunting has been also related with the lower BMI during later stages of life but greater magnitude of central obesity, though; there are ethnic differences (Walker et al, 2006; Sachdev et al, 2005). The intrauterine malnutrition also has profound impact on the increased risk of cardio-metabolic disorders (hypertension, insulin resistance, type 2 diabetes, cardio-vascular disease) (Barker, 2003). The long-term consequences of the undernutrition at later years of life has major economic outcomes (decreased school attendance, labor productivity, enhanced healthcare expenditure and tax deficit for the government) (Bagriansky et al, 2014; Bagriansky and Voladet, 2013; Laillou et al, 2012; Victora et al, 2008; Data et al, 2004; Wang et al, 2002).

On the other hand, the association of morbidity and mortality with childhood obesity is inadequately understood. Cohort studies suggest that health outcomes like atherosclerosis, coronary artery disease and diabetes are linked to both the extremes of malnourishment i.e., under nutrition and over nutrition during childhood (Tian et al, 2006; Ong et al, 2006; Barker, 2003) . Most of the available literature address correlations between body fat and proxy markers of metabolic and cardiovascular health outcomes i.e. serum lipid profile, blood sugar, fasting insulin levels, blood pressure, and measures of body fatness in children and low birth weight of children (Barker et al, 2005; Eriksson et al, 2003; Eriksson et al, 2001; Wright et al, 2001).

The occurrence of non-communicable diseases has huge economic impacts at all levels i.e., country level, household level and individual level. At the country level, they reduce the GDP of the country by 4-10 per cent (Mahal et al, 2010). The out-patient cost of non-communicable disease treatment contributes to 47 per cent of the total household expenditure. At the individual level, it has an impact on the quality of life, reduced labor productivity (Engelgau et al, 2011).Over last 2 decades the health care cost for non-communicable diseases in USA has increased by 3 times (0.43 to 1.7 % of the hospital expenses)**.** The economic burden among developing nations is difficult to estimate as most of the cost is borne by the individuals and families.

2.3. Determinants of Nutritional Status

The concept of energy balance is based on fundamental principle that energy cannot be destroyed, and can only be gained, lost or stored by an organism (Wells and Siervo, 2011). It has been consistently demonstrated that decreased physical activity, increased sedentary habits and increased consumption of high calorie food is associated with childhood obesity. The obesity epidemic is recognized to be a result of energy imbalance occurring at changes in energy intake and/or energy expenditure at individual and population levels. Genetic and individual differences in metabolic efficiency alone are insufficient to explain the recent increase in the prevalence of obesity (Strauss, 2002)**.**

In the case of undernutrition, a negative energy balance as well as inadequate intakes of protein and micronutrient would be the primary determinant. Repeated infections would exacerbate the nutritional deficiencies. Related to these other issues include household food security, poor environmental hygiene and literacy levels.

The available evidence was reviewed to understand the influence of other environmental exposures on the child's health as defined by obesogenic environment. The Obesogenic environment is defined as "*the sum of influences, opportunities, or conditions of life has on promoting obesity in individuals or populations*" (Swinburn et al, 1999). Lifestyle behavior of an individual is a result of various environment level interactions. The interactions could be either between various levels of the environment and individual or between various elements of the environment. Various existing models which discuss the multivariate determinants of energy balance related behaviors (EBRBs) include the ecological framework (Sallis and Owen, 1996; Kikbusch, 1989), ANGELO framework (Analysis Grid for Environments Linked to Obesity) (Swinburn et al, 1999), and EnRG framework (Environmental Research Framework for Weight gain) (Kremers et al, 2006). The lifestyle behavior (food consumption and physical activity) of an individual is formed by the various influencers or inhibitors permeating through various layers (household, neighborhood food environment, neighborhood built environment, school environment) contiguous to the individual.

Interventions which have been addressed so far to reverse or treat obesity has resulted in the biggest evidence gap as the interventions were ineffective (Haire-Joshu and Tabak, 2016; Rosemond et al, 2016)**.** There is wider recognition now that obesity is much more than a manifestation of prosperity and a cosmetic problem. Being a psycho-social disorder focus on behavior modification is more important than just treating it as a disease or health condition (Hoyt et al, 2014) with a focus on various settings and levels rather at only individual level. Parental and family influences appear to have crucial impact on the nutritional status of the child and especially on the current obesity epidemic (Peters et al, 2016; Cooke and Llewellyn, 2016)**.** The environmental and societal forces implicated in the obesity epidemic have been characterized as part of a "causal web" (Kumanyika et al, 2002)**.** There is need to unravel this "causal web" in respective socio-cultural contexts, as the type and magnitude of impact on the individuals and interaction among the influences seems to vary across the regions and globe.

Figures 2.1 and 2.2 describe the models given to study the determinants of overweight/obesity (Davison and Birch, 2001) and under nutrition (Black et al, 2003).

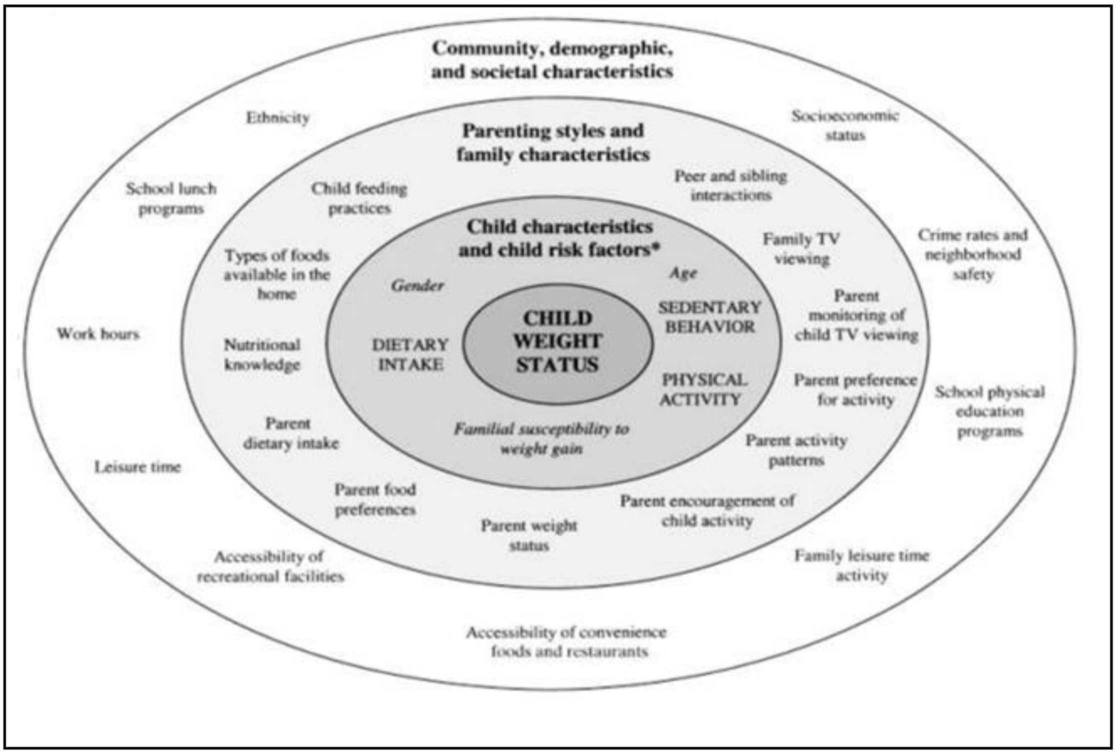


Figure 2.1: Ecological model of predictors of childhood overweight (Davison and Birch 2001)

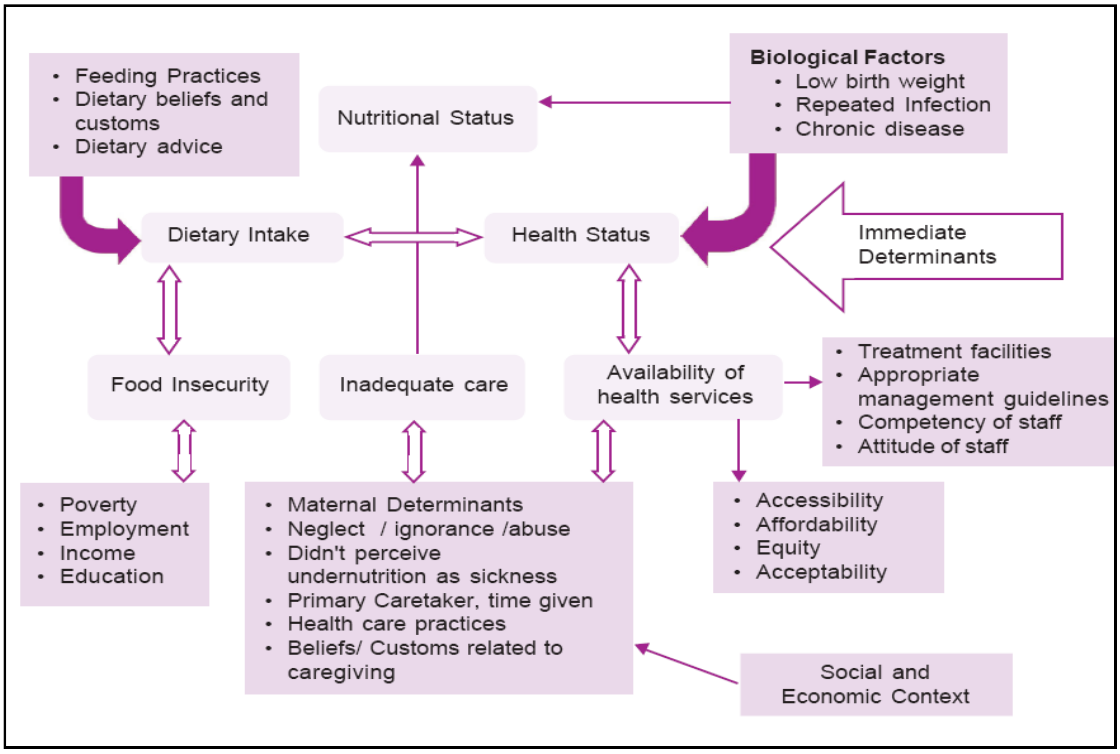


Figure 2.2: Conceptual model for understanding the determinants of under nutrition (Black et al, 2003)

The empirical model of Davison and Birch (2001) showed that child's weight status is determined by child characteristics, parenting styles and characteristics and community/demographic/societal characteristics. The child characteristics include age, gender, genetics and lifestyle behavior. With the increasing age and developmental changes in the body the decreasing levels of physical activity have been observed among girls as compared to boys (Baker et al, 2007). The parenting styles include feeding practices, nutrition knowledge, home environment, food and physical activity preference. Parental lifestyle behavior influences the dietary patterns and sedentary behavior of children (Natale et al, 2014). The community and societal characteristics include ethnicity, socio-economic status, school environment, built environment, accessibility and availability of food in neighborhood. Similarly, Black et al (2003) explained that the nutritional status of the child is influenced by the biological factors, immediate determinants and social and economic determinants (food insecurity, health care facilities, maternal determinants). The immediate determinants include dietary intake and health status. The dietary intake is assessed by the quantity of quality (diet diversity, micronutrient content) of diet (Darapheak et al, 2013). The health status is represented by disease. Any kind of infection and morbidity among children can lead to undernutrition (Checkley et al, 2008). The social and economic determinants include household food security, inadequate care and feeding practices, unhealthy household environment, household access to resources and economic context (Reinhardt and Fanzo, 2014).

The threads of the different determinants given for the extreme spectrums of dual burden when intertwined together showed that the determinants of the nutritional status among children should be viewed with a broader lens and therefore there is a need to explore and analyze behavioral, psychological, cultural, economic, and policy factors operating at different levels of the society apart from the nutrition, health and agricultural sectors (Lobstein et al, 2015; WHO 2015; Kumanyika et al, 2002). Thus, the determinants of the nutritional status among children have been described at three levels: individual level, household level and community level in the following sections.

2.3.1. Individual Level Determinants

2.3.1.1. Dietary Behavior

Dietary habits and food preferences plays an important role in the development of the nutritional status of an individual. Parents and other household members, peers, advertisements and media, the social context of eating, and possibly early feeding experience influence dietary habits of children and adolescents in infancy and genetic variation in taste preferences. Studies have shown that an increase in energy intake by 100 kcal/day results in an increase in 0.02–0.03 kg/m2 increase in BMI across gender (Wang et al, 2014).

The consumption of dairy in higher amounts in the form of full-fat milk, flavored milk, yogurt or other dairy products has an inverse relationship and lower odds of getting overweight/obese, abdominal obesity, blood pressures and insulin resistance and high levels of blood glucose (Abreu et al, 2014; Bigornia et al, 2014; Yuan et al, 2013; Lin et al, 2012). The consumption of dairy products also seemed to change with age. The different dairy products include total milk, yogurt cheese and dairy desserts. It has been shown that the consumption of dairy as beverages (i.e., consumption of milk) reduced among 9-11 year girls in Pennsylvania as compared to 5-8 year girls resulting in inadequate consumption of calcium and phosphorus (Fiorito et al, 2006).

Evidence has shown that larger portions of energy-dense foods lead to greater energy intake and thus to greater rates of obesity (Ledikwe et al, 2005). The energy density of foods has increased in terms of increased consumption of sugar sweetened beverages (SSB) and increased portion sizes. It has been shown that the individual consumption of SSB was around 540mL/week, which contributes to an excess consumption of 132 kcal; 33–40g of sugar especially in urban areas (Gupta et al, 2010). Sweetened drinks containing either sucrose alone or sucrose in combination with fructose appear to lead to weight gain due to increase energy intake (Tappy and Lee, 2010). This increase in calories from SSB is usually not compensated by a decrease in solid calories (Malik et al, 2006).

Sekiyama et al (2012) reported a high contribution of 40 per cent to the total energy intake among 1-12 year old children residing in rural Indonesia. In the same group of the children, children having higher snack intakes (≥7 years) have significantly lower HAZ scores. The intake of high energy density foods among 1-10 year old children in Malaysia was found to be significantly associated with the stunting among children (Shariff et al, 2016). The study also reported the association of low intakes of carbohydrate, sugar, vitamin C and D and higher intakes of fat, with higher energy density. Esfarjani et al (2013) identified three dietary patterns among pre-school children residing in Tehran. The dietary patterns included traditional dietary patterns, mixed dietary pattern and carbohydrate-protein dietary pattern. The authors reported that children having a carbohydrate-protein dietary pattern have lower odds of getting stunted.

On the other hand, the increasing energy intake has been identified as a major catalyst behind the process of overweight/obesity irrespective of the degree of physical activity (Jeffery and Harnack, 2007). The secondary analysis by Maunder et al (2015) showed that the contribution of different sources of total sugar intake among children (1-8.9 years) residing in rural and urban South Africa and their relationship with the micronutrient intake. Different sources of total sugar intake include white sugar, cool drinks (squash type) and carbonated cool drinks with a contribution of 60.1 per cent, 10.4 per cent and 6.0 per cent to the total sugar intake has a negative partial correlation with the micronutrient intake among children.

The increased purchasing power of a household in the count is a result of the increasing income and improved socio-economic status of the country. The dietary pattern of a population is highly subjected to the per capita GDP and urbanization of the country as shown by an ecological analysis (Siervo et al, 2013). The analysis showed that the consumption of fruits and vegetables, sugar, meat, animal fat, milk consumption and alcoholic beverages have a direct relationship with the high prevalence of overweight/obesity and hypertension (unadjusted for GDP and urbanization rates). However, when adjusted for the income, urbanization rates and physical inactivity showed that there was a direct relation of the sugar and cereal consumption with overweight and hypertension prevalence; the degree of relationship differs with the change in economic status of the country. Increased sugar intake for longer durations was also related with the high levels of blood pressure (hypertension) or deteriorating cardio-metabolic health (Stanhope 2012; Ha et al, 2012; Stanhope et al, 2012; Samuel 2011; Brown et al, 2011). The role of sugars such as fructose in the development of cardio-metabolic diseases and hypertension has been highlighted and reiterated by a review conducted by Rosset et al (2016) and a meta-analysis of the randomized clinical trials (Morenga et al, 2014). The metabolic functions behind the process include insulin signalling impairment, increased lipogenesis and vascular homeostasis disruption.

The role of sugar in the causation of decreasing BMI and high levels of blood pressure is ambiguous as shown by Parnell et al (2007). This has been reiterated by the meta-analysis and systematic review of the cohort studies (n=3 prospective cohorts; 37,375 men and 185,855 women) conducted by Jayalath et al (2014). The dual mode for the functioning of sugar intake and BMI of an individual includes the consumption of sugar-sweetened beverages and the relationship of sugar and fat ("sugar-fat see saw") (Salder et al, 2015).

Intake of sugar-sweetened beverages results in the mis-management of the satiety levels and results in the higher energy intake providing additional calories (Popkin et al, 2012). On the other hand, see saw of the sugar and fats have an inverse relationship when expressed as the total percentage energy. Salder et al (2015) explained this by a systematic review that the total energy intake by an individual is inclusive of high fat and sugar intake. However, there is an imbalance between the percentage contributions to the total energy intake. Fruit juices are being increasingly consumed as a replacement of sugar-sweetened beverages resulting in unhealthy outcomes. However, Clemens et al (2015) reported that the whole fruit consumed in the form of 100 per cent fruit juice is beneficial in improving the dietary density of micronutrients (vitamin C and potassium).

The determinants which result in higher consumption of sugar-sweetened beverages among children are recently reported by a systematic review conducted by Paes et al (2015). The determinants have been categorized at three levels: child-level (child's age, TV viewing/screen time, snack consumption and child's knowledge), interpersonal level (lower parental socio-economic status, lower parental age and parental SSB consumption) and environmental level (attending out-of-home care, home availability of SSB and living near fast food store). Parental modeling, healthy school policies and living near a supermarket were found as positive determinants in reducing the SSB consumption.

The increasing protein intake during infancy or early childhood also increases the risk of obesity in late childhood or adulthood as suggested by the “early protein hypothesis” (Xu and Xue 2016). The relationship of higher intake of macronutrients during childhood and increased risk of obesity has been reiterated by the longitudinal studies implemented across various parts of the world (Gunther et al, 2007; Kroke et al, 2004; Scaglioni et al, 2000).

The meta-analysis of the feeding trials has shown that the consumption of pulses and legumes in the daily diet lowers the risk of chronic disease and improved dietary quality by enhancing the satiety level of the food consumed (Li et al, 2014).

The high consumption of salt is also associated with higher odds of an elevated systolic blood pressure and higher waist-to-height ratio (Funtikova et al, 2015). The consumption of nuts has been reported to have a beneficial role in predicting the prevalence of obesity among children and adolescents (Matthews et al, 2011).

There are also increasing intakes of ultra processed foods among children in Brazil (47%) and Canada (61%) (Sparrenberger et al, 2015; Moubarac et al, 2013). The ultra-processed foods in the studies were defined on the basis of classification proposed by Monteiro et al (2010). The consumption of these ultra-processed foods has resulted in the deficiency of micronutrients (vitamin B12, vitamin D, vitamin E, niacin, pyridoxine, copper, iron, phosphorus, magnesium, selenium and zinc) in the daily energy intake of Brazilian population (Louzada et al, 2015).

On the contrary, fruits and vegetable have a protective effect against many chronic diseases and overweight (NNMB, 2012). However, the role of plant-based diets have also been questioned due to lack of consistency in their relationships with the decreasing levels of BMI and the prevalence of overweight as shown by a systematic review (Newby, 2009). Dietary patterns were derived in the Malaysian Adolescent study by using data reduction technique (principal component analysis) and were classified in three major categories/domains i.e., ‘healthy pattern’ (characterized by a high proportion of fruits, vegetables and dairy products), 'western-based pattern' (high in animal-derived and processed foods), and 'typical-dietary pattern'. Multivariate logistic regression analysis found that adolescents who had higher intake of western-based diet pattern had higher odds of being obese (OR: 7.6; $p < 0.001$), as compared to those eating healthy diet (OR: 5.0; $p < 0.001$) (Foo et al, 2014). Among the European countries, there have been reported large variations in the consumption of fruits, vegetables, sweets and soft drinks. On analysis no significant relation was found between overweight and fruit, vegetable and soft drink intake. But there was significant (<0.05) negative relationship between the intake of sweets (candy, chocolates) and BMI classification in 31 of 34 countries studied (Janssen et al, 2005). There was a preference for energy dense foods among children irrespective of the food category (Kral et al, 2007).

Arora et al (2012) observed a dose–response relationship such that overall prevalence of overweight and obesity among adolescents who consumed breakfast daily (14.6 per cent) was significantly lower vs. those who only sometimes (15.2 per cent) or never (22.9 per cent) consumed breakfast ($p<0.05$ for trend). They also observed that physical activity positively correlated with breakfast consumption.

2.3.1.2. Psychology of Eating Behavior

The behavioral trait which is responsible for an increase in the food intake is called as impulsivity. Impulsivity is defined as the tendency to think, control and plan insufficiently. Impulsive behaviors can be categorized as reward-related impulsivity (sensitivity to reward/inability to delay reward) where the immediate smaller reward become the preference over the delayed larger rewards and insufficient inhibitory self-control over behavior (Nederkoorn et al, 2006a; Nederkoorn et al, 2006b). Children with impulsive traits usually make hurried decisions, act at the spur of the moment and display unpredictable behavior. Thus, the impulsive behavior results in increased food intake leading to overweight/obesity. These behavioral traits possessed by an individual are defined by the Gray's biological theory. These systems are defined as behavioral approach system (BAS) and behavioral inhibition system (BIS). The personality associated with BAS is associated with the anxiety and approach behavior. The individual with this trait are more sensitive and attentive to signals of reward resulting in an impulsive behavior (Beck et al, 2009; Carver and White, 1994).

Food has more rewarding stimulating cues as compared to any other thing. Food is being used as a reward while parents feed their child. The reward can be in the form of unhealthy snacks. The reinforcing effect of food and the resulting eating behavior of an individual is tied to reward brain pathways (Wang et al, 2004; Killgore et al, 2003) mediated in part by dopaminergic systems (Epstein et al, 2007; Wise, 2006). Feeding or presence of palatable food or appetitive food-related cues, leptin, ghrelin, and other regulators of appetite activates the dopamine pathway in humans results in dopamine release in the dorsal striatum and the degree of pleasure from eating correlates with the amount of dopamine released (Abizaid et al, 2006; Small et al, 2003).

The BIS/BAS scale has been validated among Norwegian children (11-12 year old) and suggested that the scale assesses the personality of children as per the Gray's biological theory. The environment has been confronted with an increase in the availability of food items, large portion sizes, increased accessibility and affordability of food items. These changes contribute to the activation of hedonic system which in turn is responsible for increasing the food intake. When stimuli are present in our environment reward-sensitive people are prone to approach the stimuli. The interaction between the reward sensitivity and caloric intake is more significant when there is a variety of food available in the environment. The causal inference between the role of impulsivity on overweight/obesity is a lacunae in the current research. Obese children besides eating seem more vulnerable for food triggers, like the smell and taste of the food, than the lean children (Jansen et al, 2008). It has been suggested that poor control of neural centers related to impulsivity and/or addiction could foster impaired control of food intake, leading to overeating and subsequent overweight (Cortese and Vincenzi, 2012). Adaptive decision-making and the ability to delay gratification may influence eating behaviors, particularly in a food environment where effortful control of energy intake is essential for the maintenance of a healthy body weight (Davis et al, 2004).

Guerrieri et al (2008) investigated that children who do not have weight problems yet are also more sensitive to the diverse food environment surrounding them. The individuals with high BAS levels are more reward sensitive exhibiting high levels of impulsivity. This component of behavior deals with the appetitive stimuli. The individuals with high BIS levels have greater levels of anxiety and are more prone towards aversive stimuli showing avoidance or withdrawal behavior. The study reported that children who were sensitive to reward consumed a greater variety of food items resulting in consumption of excess calories. Scholten et al (2014) conducted a cross-sectional observational study among 8-12 year old children in Netherlands the role of unhealthy snack consumption as catalyst in the relationship between the impulsive traits and overweight/obesity. The study showed that the children with higher BMI z-scores were from the low socio-economic status families, unhealthy snacks were majorly consumed in children with higher disinhibition scores i.e., children having higher levels of self-control and low BMI z-scores.

Important individual differences have been reported in these neural responses to food cues (Beaver et al, 2006) highlighting potential individual variations in sensitivity to the reward properties of food (reward-seeking phenotype). In fact, a recent study showed that the individual differences in one’s responsiveness to rewarding environmental cues is the most powerful predictor of the 25 additional pounds gained by the typical adult between 20 and 50 years in most westernized countries (Hays et al, 2008). High-reward seeking individuals are found to be vulnerable to a high density of fast food in their home neighborhood (Pacquet et al, 2010). Foods with higher energy density those rich in fats, extracted sugars, and refined starches-are unwittingly consumed in greater amounts, reiterating that the density of a food item is the major determinant of intake as compared to the macronutrient content of the food (Prentice, 2003; Raben et al, 2003; Raben et al, 2002; Drewnowski, 1998; Cotton et al, 1996; Stubbs et al, 1995). Nevertheless, the urge to eat sugary and salty foods is driven by selective taste buds and neuronal projections to the limbic pleasure centers, and the combination of the fats and sugars, rare and precious in our early evolution, is especially alluring (Popkin et al, 2012). When displayed in larger proportions, the visual impact of food dominates appetitive regulation in children older than about 4 years so they consume more (Onlet et al, 2003). Therefore, food intake is mediated by a myriad of factors ranging from the behavioral impulsive trait of the individual and availability of a variety of obesogenic food items in the neighborhood or household environment.

2.3.1.3. Physical Activity

Physical Activities in Children: A Heterogeneous Variable

Childhood is a period which naturally involves lot of physical activity which falls into a set pattern with increasing age. Physical activity can be classified into structured and unstructured activities. The unstructured activities cause energy expenditure but they vary in duration and vigor, they are difficult to quantify (Mota and Esculcas, 2002). These includes jumping child around the house, fighting with sibling or friends, running around, playing hide and seek in the evening, runs and get supplies from the nearby grocers store or help parents in household activities. On the other hand, structured physical activities like jogging, skipping, sports other forms of physical exercise can be quantified and contributes to a small percentage of the child's daily physical activity. Another domain of physical activity that has been is sedentary habits developed among children as a result of nutrition transition (Popkin et al, 2012). It must be realized that hours of increased physical activity can co-exist with a sedentary lifestyle in children. In literature, physical activity and sedentariness among children are measured using various indicators/surrogate measures resulting in heterogeneity in the interpretation of results given by various research studies. These surrogate indicators include school based health survey questionnaire, participation in sports, physical exercise (time and frequency), time spent in outdoor activities/play, duration of physical activities across domains and mode of transport to school, TV viewing time, playing computer and video games.

Determinants of Physical Activity Behavior

Physical activity in children is a complex behavior determined by family, personal, school, socio-cultural and physical environmental influences (Bauman et al, 2012). The demographic characteristics which have influences the physical activity among children includes gender, age, education, ethnicity, and income level (Boone-Heinonen et al, 2010; Belanger et al, 2009; Ries et al, 2008). Other correlates and determinants which have been associated with or influencing physical activity among children and adolescents include self efficacy (it is described as the confidence in being physically active in specific situations), perceived behavioral control (it is described as the perception of the ability to be physically active), valuing physical activity for being healthy (appearance or achievement) (Craggs et al, 2011; Van Der Horst et al, 2007; Biddle et al, 2005; Sallis et al, 2000).

Enjoyment appears to be another factor that determines the activity levels among both children and adults (Allison, 1999). Different sets of predictors may be important across age groups and for sex. There is practically no data from LMIC about the perceived facilitators and barriers to physical activity behavior in children. Some data from developed countries suggest that perceived barriers to physical activity in children and youth may be external; lack of support from friends and family members, low resources, lack of time due to school home work, internal or psychological barriers; lack of motivation, lack of confidence and ability, and fear of injury (Bauman et al, 2012).Sedentary behavior compounds the problem by encouraging in between snacking and passive consumption of energy-dense foods (Tremblay et al, 2011; Borzekowski and Robinson, 2001). Psycho-social and environmental determinants also have an impact on the physical activity levels of children especially obese children. These include community and parental participation in doing physical activity, perception regarding exercise, increasing community awareness and self-efficacy of doing physical activity (Trost et al, 2001).

Physical Activity and Nutritional Status of Children

With advent of mechanized transport, other technologies to share physical activity of man and due to various socio-cultural changes, the ‘normal’ amount of physical activity in human in decreasing day by day. This has affected the adult and the child similarly. A secular trend has been observed, though inconsistent, showing the decrease in physical activities among children and adolescents (Smpokos et al, 2012; Sigmundova et al, 2011; Tambalis et al, 2011; Al-Hazza and Al-Rasheedi, 2007; Kelishadi et al, 2005). The trend in decrease in physical activity among children in India is more consistent despite the use of different methodologies, outcome parameters, sample size and location (Swaminathan et al, 2013).

The relationship between physical inactivity and childhood obesity has been documented consistently across different ethnicities and cultures including India

(Mozaffari and Nabaei, 2007; Ness et al, 2007; Rauner et al, 2000). Although the increase in childhood obesity is frequently attributed to a decline in physical activity, a remarkable lack of consistency exists in the relationship between reported level of physical activity and degree of fatness (Hainer et al, 2009; Parsons et al, 1999). Over the years there is reduction in physical activity level among school children and adolescents across the globe. A number of studies have revealed that BMI and adiposity decrease and energy expenditure increases in people regularly engaged in sports activities (Ross and Janssen, 2001).

In a study among 100 British children aged 6-8 years who were at high risk of future obesity (≥1 obese parent), physical activity level (measured using 7-day doubly labeled water measurement and heart rate monitoring) was compared with body composition (isotope dilution method). Children in high risk group had significantly higher weight ($p<0.05$) and BMI ($p<0.01$) than the low risk children. Janssen et al (2004) had assessed the relation between physical activity and dietary habits with obesity status among 5890; 11-16 year old Canadian adolescents. The study observed that there was significant negative ($p<0.05$) relationship of BMI with the fruit intake and physical activity while positive ($p<0.05$) relationship with TV viewing and consumption of snack foods and soft drink**.**

Gender differences have been also observed regarding physical inactivity among children and adolescents (Vilhjalmsson et al, 2003; Trost et al, 2002). The factors influencing girl's levels of physical activity include age, presence of same gender peer group, different types of activities which are socially designated for males and females respectively, restricted mobility of the girls to participate in physical activity and perceived barriers as psychological correlates for physical inactivity. These barriers include weather conditions, physical appearance and inconvenience for playing. This could be due to higher degree of self-consciousness while physical activity with boys, messing up with hair and make-up, less preference to males for training, cultural inhibitions and less self-motivation (Sabo et al, 2004; Fairclough et al, 2002; Greendorfer et al, 2002; Flintoff and Scraton, 2001; Sallis et al, 2000; Shepherd and Trudeau, 2000; Kirk et al, 2000).

Apart from BMI, structured physical activity also has a positive relationship with the central obesity after adjusting for BMI (Klein-Platat et al, 2005). More than 40 per cent of girls and 25 per cent of boys did not practice any structured physical activity outside school. High-level of sedentariness (>2hr/day) was seen to increase BMI by 0.7 kg/m^2 and 0.4 kg/m^2 among boys and girls respectively. Structured physical activity of > 2hrs 20 min/week was associated with decrease in waist circumference of 1.6 cm and 1.8 cm in boys and girls respectively. In a study among urban south Indian children (n=4700; 13-18 years), prevalence of obesity and BMI were inversely related to the physical activity score ($p<0.001$). Overweight prevalence was also positively correlated with higher economic status ($p<0.001$) and higher birth weight ($p<0.001$) among both the genders (Ramachandran et al, 2002).

In a study among adolescents (12-17 years) from Hyderabad, the prevalence of overweight and obesity was significantly higher (10.4%) among those who watched TV > 3 hours/day, and lower among those engaged in outdoor play >6hrs/week (3.1%) and household activities >3 hrs/day (4.7%). The odds of being overweight was higher among adolescents watching TV (OR=1.92; CI: 1.16-3.18) and less involved in outdoor games (OR=2.75; CI: 1.56-4.72) (Laxmaiah et al, 2007). Physical inactivity has been found to be more prevalent among girls compared to boys and there is a large deficit in their participation in outdoor games and sports. Corder et al (2010) in their study on adolescents in Chennai demonstrated lower levels of physical activity energy expenditure derived from double labeled water technique. Similar declining trends in moderate to vigorous physical activity (MVPA) were observed by Swaminathan et al (2011) over a single year follow up. The available data from West Bengal, India suggests that the children without regular physical exercise had higher BMI, skin folds, percent body fat, fat mass and fat mass index compared to the children who undertake regular physical activity. Covariate analysis revealed that physical exercise has a significant negative effect on all measures of body fat composition (percent body fat, fat mass and fat mass index) with age as covariate even after controlling for impact of age (Mukhopadhyaya et al, 2005).

2.3.1.4. Sedentariness

Sedentary behavior defined as engagement in sedentary activities like television watching, increased duration of screen time is one of the major risk factor for obesity (Tremblay et al, 2010; Troiano et al, 2008). The increased duration of sedentary activities has been associated with hypertension, metabolic syndrome, fasting insulin levels, higher HbA1C levels among children (Aman et al, 2009; Lazarou et al, 2009; Overby et al, 2009; Dasgupta, 2008; Mark and Janssen, 2008; Wells et al, 2008; Sugiyama et al, 2007; Ekelund et al, 2006). Tremblay et al (2011) conducted a systematic review (n=232 studies; 9, 83, 840 participants) to determine the relationship between sedentary lifestyle and various health/behavioral indicators among children and youth (5-17 years). The study found that there is a dose response relationship between childhood obesity and TV watching as had been documented form cross sectional studies, longitudinal studies and randomized controlled trials. Watching television or screen time of more than 2 hours per day was associated with lowered scores of self esteem, academic achievement and pro social behavior and higher BMI and decreased fitness.

The duration of TV watching increases with age especially in children who have a TV in their bedroom. The study reported that there was a 1.31 times higher odds of children getting obese who watch television in their bedrooms and it also increases the time spent watching TV by average of 38 minutes per day (Dennison et al, 2002; Wiecha et al, 2001). This relationship between adiposity and TV viewing was stronger in low SES population (Dennison et al, 2002). There was higher television watching among children who seldom attended family dinner, experiencing no parental restriction on television watching (Wiecha et al, 2001). Among children, television watching has been associated with change in eating behavior like increase in casual snacking and modulating eating habits through exposure to advertisements for food high in sugar and/or fat (Lobstein et al, 2004).

In a meta-analysis by Marshall et al (2004), TV viewing was significantly ($p < 0.05$) associated with body fatness ($r = 0.066$; 95%CI: 0.056-0.078; $n = 44,707$) among children. Although the relationship was statistically significant, the fact that 99per cent of variance in body fatness may be explained by factors other than TV viewing calls into question the clinical relevance of this association. TV viewing was negatively and significantly ($p<0.05$) associated with physical activity ($r = -0.096$; 95% CI: -0.80 to -0.112; $n = 1,41,505$) after being adjusted for other biases. Further analysis reflected that only vigorous activity was significantly associated with TV viewing and was potentially confounded by other factors like consumption of energy dense snacks that may accompany these behaviors.

There is a documented evidence regarding the relationship between the sedentary activities like TV watching of less than 2 hours, playing video or computer games with overweight and obesity (Jain et al, 2010; Pandher et al, 2004). A positive relationship of physical activity like exercise, sports, sleeping habit in afternoon has been observed on the prevalence of overweight and obesity among middle to high SES group in Ahmadabad (Goyal et al, 2010).

Faith et al (2001) tested the effects of contingent TV system on obese children's physical activity (n=10, 8-12) and TV viewing in home environment over 3 months. The intervention significantly improved physical activity and reduction in TV watching duration. During the treatment phase, the experimental group pedaled 64.4 min per week on an average compared to 8.3 min in central group. TV watching was 1.6 hrs per week among the experimental group while it was 21.0 hours in central group. Body fat analysis resulted a reduction in body fat (-1.2 % on average) compared to increase among central group (0.9%). Authors opined that this system may be an intervention modality targeting at both reducing TV viewing and increasing physical activity.

2.3.1.5. Sleep Behavior

Sleep duration is considered as one of the risk factors for obesity specifically among children and act as a cardio-metabolic risk factor. Physiologically the total "sleep need" has been defined as nine hours of night sleep which has been found to reduce among children and especially adolescents to 8.4 hours per night. Sleep duration categorized as short (<7 hours to ≤4 hours every night) and long (>8 hours to ≥12 hours every night) has been defined differently by different research groups (Cappuccio et al, 2010). The relationship between sleep behavior and risk of obesity has been explained by mechanisms/pathways functioning at behavioral level or endocrinal mechanisms. At behavioral level, it is explained by increasing opportunities for food intake and increased appetite when there is reduced total sleep duration. This in turn might lead to reduced duration of sleep leading to fatigue and thus reduced energy expenditure (Cauter and Knuston, 2008).

Spiegel et al (1999) conducted one of the first experimental based research study – "The Sleep Debt Study" to assess the effect of recurrent partial sleep deprivation in alterating the plasma levels of satiety and appetite stimulating hormones (leptin and ghrelin respectively). The subjects were subjected to a sleep debt and sleep recovery of 4 hours for 6 days each respectively and leptin levels were assessed. The leptin levels reduced by 19 per cent when the sleep duration was 4 hours as compared to 12 hours of sleep duration.

Cappuccio et al (2011) conducted a meta-analysis (n=24 cohorts) including 4, 74, 684 subjects from 8 countries with more than 5 years of follow-up in all the cohorts. It showed that there is a higher risk for developing total cardiovascular disease among individuals with short sleep duration (RR: 1.03; 95% CI: 0.95-1.15: p-value: 0.52) and long sleep duration (RR: 1.41; 95% CI: 1.19-1.68; p-value<0.0001). Similarly, short sleep duration possess inverse relationships with the other cardio-metabolic risk factors like hypertension and insulin resistance (Mesarwi et al, 2013; Spiegel et al, 2009; Gangswich et al, 2006). At physiological level, sleep deprivation leads to increase in urinary and plasma catecholamine levels, reduced utilization of glucose by brain and increased levels of circulating levels of glucose and lastly increase in the level of cortisol. These changes at the metabolic level increase the burden of insulin, compromising the beta-cell function and leading to the development of Type 2 diabetes (Gangswich, 2009). The values of blood pressure are usually lower while sleeping and gradually increase after waking up and awakening. But during the reduced sleep duration average blood pressure tends to increase with elevated sympathetic nervous system activity, waking physical and psychosocial stressors. The increased stress increases the consumption of salt in diet suppressing the renal salt-fluid excretion. Thus, long exposure of sleep deprivation might lead to increase in blood pressure and thus hypertension. But the role of sleep deprivation on hypertension among children has not been studied extensively.

Meta-analysis conducted by Cappuccio et al (2008) including a sample size of 30,002 children in the age range of 2-20 years, the reduced sleep duration has a higher pooled odds of 1.89 (95% CI: 1.46 to 2.43; p<0.0001) of resulting in childhood obesity. Hart et al (2013) conducted an experimental study among children in the age group of 8-11 years of age from New England (n=37). Children were randomized to either decrease or increase the total sleep duration by 1.5 hours per night for one week followed till three weeks as measured using actigraphy and outcome was measured in terms of the weight of the child. The mean difference in the weight of the children of two groups was 0.22 kg (weight increased where sleep duration decreased) and associated effect size of d=0.95 (p < 0.001). The experimental study also found that an increase of 141 minutes of night sleep had resulted in a reduction of total caloric intake by 134 kcal/day. This association differs between different age groups but short sleep duration and obesity is strongly associated across pediatric population (Patel et al, 2008; Chen et al, 2008).

Sleep deprivation also impacts the BMI and abdominal obesity among children. Ping et al (2012) have demonstrated among 6,576 children (7-11 years of age) studying in the primary schools of the metropolitan cities of China that there was higher odds of being overweight and obese among children, measured using BMI (OR 1.29, 95% CI 1.01 to 1.64, p=0.045) and abdominal obesity (OR 1.38, 95% CI 1.04 to 1.83, p=0.028) who slept less than 9 hours every night when compared to children sleeping for 10.0-10.9 hours per night. Research studies have demonstrated that the sleep duration and sleep efficiency increases if the BMI, central obesity, waist-to-height ratio decreases but the effect size is small to explain the causality (d≤0.05) (McNeil et al, 2014; Lee et al, 2012; Carter et al, 2011; Bayer et al, 2009; Touchette et al, 2008; Nixon et al, 2008).

Bornhorst et al (2015) conducted a study in 13 countries included in the World Health Organization (WHO) European Childhood Obesity Surveillance Initiative (COSI) among 6-9 year old children (n=10, 453). They demonstrated that odds of frequent consumption (≥4 time per week) of *chips, biscuits/cakes, pizza/burgers, chocolates/candy bars* was higher among children who have reduced sleep duration

(<9.7 hours per day) and the higher screen time (≥2 hours per day). McNeil et al (2014) also the relationship between physical activity and sleep patterns using an actigraph GT3X+ among children (9-11 years of age; n=567) and demonstrated that increase in total time in minutes spent in light physical activity and sedentary activities significantly decreases the sleep duration when adjusted for the percentage body fat with a higher effect size (≥0.14). Along with sleep duration there are other domains of sleep behavior including sleep disturbances and sleep patterns which are significantly associated with the obesity indicators i.e., body circumferences, BMI and percent body fat (Hjorth et al, 2014; Jarrin et al, 2013). The presence of television in the bedroom significantly reduces the sleep efficiency which in turn is more strongly related to the adiposity among children (Chaput et al, 2014).

Poor sleep efficiency and reduced sleep duration significantly increases the daily requirements of individual energy expenditure. Consequent to the increase in energy intake, increased intake of foods rich in carbohydrates with distorted eating behavior in terms of dietary restraint resulted in the weight gain (Markwald et al, 2013; Kim et al, 2011; Westurland et al, 2009). But the increase in food intake could be explained by increased opportunity for eating food (Chaput and St-Onge, 2014) and availability of modern obesogenic foods at the household and neighborhood level (Markwald et al, 2013). Meta-analysis by Chapman et al (2012) has also shown that short sleep duration is a potential factor for increasing the food intake of an individual with a higher effect size (Cohen's d = 0.49; 95% CI= 0.11-0.88; $p<0.05$).

Chaput et al (2014) have also demonstrated that reduced duration of sedentariness day and increased duration of sleep can reduce body fat percentage points by 0.36 percentage points. There have been mixed results regarding the relationship regarding sleep duration as an independent risk factor for higher MVPA minutes and adiposity among children (Williams et al, 2014; Taveras et al, 2014).

Sleeping patterns have a significant impact on the dietary behaviors in all the stages of childhood. Fisher et al (2014) assessed the sleep behavior and dietary patterns in a cohort of children in their early childhood (5-29 months of age) from United Kingdom. They demonstrated that children with a short sleep duration had a significant higher adjusted energy intake (p=0.005). Fat (estimated difference=3g per day; 95% CI 0.5-6; p=0.02) and carbohydrate (estimated difference=10 g per day; 95% CI 2-17; p=0.01) intakes were significantly lower in children who were sleeping for a longer duration.

Among Indian children the mean duration of sleep has been reported as 8.77±0.80 hours (Bharti et al, 2006). Ravikiran et al (2011) assessed the sleep problems among children (2-12 years of age; n=513) in rural parts of Karnataka, India showed that in more than 51 per cent of children had at least one of the five sleeping problems.

In a cross sectional questionnaire based study among apparently healthy children from Bangalore (n=598; 6-16 years), 6.4 per cent of the children were overweight. The children who slept less than 8.5 hours a day had significantly higher odds (6.7; p=0.013) of being overweight, compared to the children sleeping more than 9.5 hours a day. Similarly the children watching TV for more than 1.5 hours a day had higher odds of being overweight (19.6, p=0.001) compared children watching TV for less than 45 minutes a day. The duration of sleep and TV viewing were significantly associated with the BMI of children (Kuriyan et al, 2007).

Anuradha et al (2015) has also demonstrated among Indian adolescents from South India that reduced sleep duration (<7 hours per day) has 2.0 time more risk (95% CI: 1.194-3.371) for being overweight as compared to those sleeping > 9hours per day. In conclusion, it has been shown from both experimental based and epidemiological based research studies that when sleep is restricted or reduced, the energy intake increases majorly from carbohydrates and fats due to eating behavior distortion, alterations of hormonal regulation at the physiological level. This result in increased energy intake and increased time spent in sedentary activities. These changes in the lifestyle behavior further act as risk factor for overweight/obesity, diabetes and cardiovascular diseases. But the role of sleep as an independent risk factor of lifestyle behavior especially physical activity for these cardio-metabolic diseases remains an unanswered research question.

2.3.2. Household Level Determinants

At the household level, there are multiple factors influencing the child's nutritional status. These include socio-economic status, household characteristics, the availability and accessibility of food items in the household, parenting styles and feeding styles. The valid assessment of these measurements requires a concrete measurement indicator. The household been documented as one that can either facilitate or inhibit the healthful eating and physical activity, and caregivers play a key role in the development of the social and physical environment within a household (Rosenkranz et al, 2008).

2.3.2.1. Household Characteristics and Socio-economic Status

The household socio-demographic characteristics play a pivotal role in the development of the nutritional status of a child. The housing characteristics like kutcha house, urban/rural location, socio-demographic characteristics have a bearing on the nutritional status of the child (Alelign et al, 2015). The possession of the livestock in the household significantly reduces the risk of stunting among children (Mosites et al, 2015).

The determinants of undernutrition among children were studied among children in 30 cities of Iran by Kavosi et al (2014). The authors reported that childhood malnutrition is associated with the following predictors: urbanization (settlement in urban areas), large family size, family income, poor water supply, access to health services and maternal education. The other predictors but insignificant reported in the study includes parental occupation, birth weight, paternal education and parity. Martorell and Young (2012) reported that maternal body composition is also one of the potential risk factors for the prevalence of stunting and wasting among children.

The pooled data of 10,366 children from three Demographic and Health surveys in Cambodia reported a high prevalence of stunting among children younger than 5 years of age and significant causative factors included child’s age and sex, maternal height and BMI, diarrhoeal episodes among children, paternal education, household’s socio-economic status, access to improved sanitation facilities, maternal tobacco use (Ikeda et al, 2013).

Kanjilal et al (2010) conducted a secondary analysis using multi-level modeling to assess the relationship between socio-economic in equality in any health outcome with the nutritional status of the child. The analysis reported that there has been decrease in the prevalence of under nutrition over the period of years has reduced in the country with wide variations but still the concentration of the issue is higher in households with poor socio-economic status residing in urban areas as compared to rural counterparts.

Darteh et al (2014) assessed the determinants of stunting at household using the Ghana Demographic and Health Survey data, 2008. Mother's age during child birth, number of children in the household and socio-economic status of the household was found as the factors determining stunting among children.

Meshram et al (2012) conducted a community based cross-sectional study among under five tribal children in nine states of India. The study found that the major determinants of stunting among tribal children included maternal illiteracy (OR: 1.5; 95% CI: 1.4-1.7) and low socio-economic status (OR: 1.5; 95% CI: 1.4-1.6). The determinants of wasting in the same group of children were living in overcrowded families (OR: 1.3; 95% CI: 1.1-1.6), maternal illiteracy (OR: 1.4; 95% CI: 1.2-1.6) and history of morbidity in the past 15 days (OR: 1.3; 95% CI: 1.1-1.4).

Another cross-sectional survey conducted in Bhubaneswar, India among 3-9 years of children to assess the determinants of under nutrition (indicators: wasting, underweight and stunting) among children. The significant determinants of under nutrition among children were found to be birth order of child, initiation of breastfeeding, mother's education, type of toilet facility in the household and practice of drinking water storage (Panigrahi and Das, 2014).

A cross-sectional study conducted in urban slums of Bareilly (Uttar Pradesh), India among 5-15 years (n=512) of children reported that joint family (OR: 4.5; 95% CI: 2.96-6.9), >2 birth order (OR: 3.37; 95% CI: 2.33-4.88), maternal education of less than 6^{th} standard (OR: 5.15; 95% CI: 3.46-7.65) and working mothers (OR: 6.1; 95% CI: 4.16-8.97) were significant predictors of undernutrition among children (Srivastava et al, 2012). Authors reported paternal education and occupation, breastfeeding and gender of the child as insignificant predictors of undernutrition among the sampled children.

Mothers education plays a pivotal role in the weight status of the child. The prevalence of overweight/obesity is found to be higher among children whose mothers are highly educated in different parts of the world (Dearth-Wesley et al, 2011; Chakraborty et al, 2010; Maddah et al, 2010). The paternal occupation was also reported to be significantly associated with the higher odds of stunting and wasting among 5-18 years of young children (Mekonnen et al, 2014).

Household facilities and socio-demographic characteristics were also associated with the status of undernutrition among children. The household socio-demographic characteristics and self-hygiene indicators like “absence of toilet at home, use of untreated drinking and cooking water, bathing in river, not washing hands before eating food/after playing with animals, not washing fruits/vegetables before consumption and not wearing shoes when outside” significantly increases the odds of getting Giardiasis infection (Choy et al, 2014). The major modes of transmission of infections are through contaminated food and water resulting in fat mal-absorption and lactose intolerance (Choy et al, 2104; Buret 2008).

Spears et al (2013) conducted an ecological analysis to reiterate the already established relationship between open defecation and stunting among children. The data for the ecological analysis was obtained form 112 districts from Census of India database (Census, 2011). The authors reported that open defecation (R^2: 34.5%) and female literacy (R^2:48.5%) were two major predictors of the growth parameters during childhood.

Alelign et al (2015) has reported that the odds of the prevalence of underweight among 5-14 year age old children increases with an adjusted odds of 3.13 when children do not wash their hands before eating food and prevalence of anemia increases by an odds of 8.9 among those who have hookworm infection. Literature has shown that any kind of morbidity (infections, diarrhea or fever) affect the utilization of nutrients in among children and hence leads to chronic or acute malnutrition (Herrador et al, 2014; Amare et al, 2013; Mahmud et al, 2013). Lower dietary intakes are associated with the poor socio-economic status and poor diet quality and hence greater magnitude of undernutrition (Petrauskiene et al, 2015; Shariff et al, 2015). The household dynamics in the procurement of food and degree of urbanization of the place of residence (Mayen et al, 2014) also has implications on the diet intake and nutritional status.

The household demographic factors play a role in the governing the morbidity status of the child and thus the nutritional status (Lin et al, 2013). The authors reported that the children residing in households with clean environmental conditions in Bangladesh have lower magnitude of the environmental enteropathy indicators and higher z scores of Height-for-age. The source of drinking water also had impact on the child's growth (Kamal et al, 2015). The solid bio-mass used a cooking fuel has been also related with the higher prevalence of stunting and anemia among children in India (Mishra and Retherford, 2006).

Thus, the socio-demographic status, sanitation and hygiene facilities, source of water, clean fuel used in household, morbidity among children measured as repeated occurrence of infections, higher density in the household, maternal weight and height, maternal and paternal education and occupation, parity and seasonal disparity especially rainy season are all significant determinants of dual burden among children (Chirande et al, 2015; Kavosi et al, 2014; Ramirez-Zea et al, 2014; Bygbjerg 2012; Meshram et al, 2012; Martorell and Young 2012; Srivastava et al, 2012; Kanjilal et al, 2010; Wamami et al, 2007).

2.3.2.2. Parental Modeling

Parents influence their children's dietary practices, physical activity, sedentary habits, and body satisfaction by controlling availability and accessibility of foods, meal structure, and food-related parenting style (Davison and Birch, 2001). Research shows that parents mould children's behavioral patterns by their own behaviours (i.e. social modeling) and by parenting practices such as the types and quantities of foods parents present to children, their support of children's extracurricular sporting activities, and their monitoring of children's access to television, videos, and computer games. These practices are influenced by characteristics of the child, such as a child's age, gender, and weight status (Scaglioni et al, 2011).

Parents powerfully shape children's early experiences with food and eating, providing both genes and environment for children though parental conduct regarding child's dietary behavior through different styles and practices (Savage et al, 2007; Ventura et al, 2008; Scaglioni et al, 2011). Parents develop a feeding environment at home by enabling the availability and accessibility of food items in the household; which in turn develops the eating behavior among children, shapes their references, likes and dislikes and food acceptance (Cooke, 2007; Birch, 2002). Child feeding practices includes pressuring children to eat certain foods, restricting child's access to foods which are driven by their own eating behavior and child's current weight status especially among girls (Joyce et al, 2009; Savage et al, 2007; Birch et al, 2003).The acceptability of the food item in the household as facilitated by the parent is one of the major determinant of food intake among children (Cooke 2007; Pliner and Stallberg-White 2000). Thus, food preferences among children are the product of various factors including socio-demographic profile of the household, household food environment, parental influences and genetics factors (Scaglioni et al, 2011).

Jansen et al (2012) conducted a cross-sectional study in Netherlands and assessed the four year old pre-school children who participated in the Generation R cohort. The children were assessed for their eating behavior and BMI. The study found that the children who enjoy eating food had 1.28 times higher risk for becoming overweight and 0.78 times higher for underweight children as compared to normal weight children. On the other hand, if the child was pressurized to eat then there was 1.3 times of higher risk of becoming underweight and 0.66 times of becoming overweight as compared to normal weight children. Though these differences in the eating behaviors are independently associated with BMI but they have an initiation at an early age.

Parents appear to be the primary influence on the physical activity behavior of their children, through either direct (by providing a supportive, nurturing environment) or indirect (through modeling) means or, more likely, as an interaction of the two or children's perception of their parent behavior (Craggs et al, 2011; Edwardson et al, 2010; Van Der Horst et al, 2007; Biddle et al, 2005; Sallis et al, 2000). Parents also regulate the sedentary activities of their children. Parents perceived barriers and concerns about their children's physical activity vary from that of their children; this however needs to be studied in different cultures. With lack of facility, family, and social support for recreational physical activities and concern for safety and pollution, children are progressively confined to home adopting sedentary options in several high income societies. Similarly, involvement of mothers in organized sports and walking exercises, presence of outdoor play equipments in the backyard and greater backyard size was significantly associated with the higher outdoor playtime of children. Though there have been studies which have shown that father's participation in physical activity has a greater influence on children's outdoor play activities. The study has also shown that the higher involvement in sedentary activities are the driving forces for the obesity epidemic mediated by the dietary patterns which in turn is related with home environment (Spurrier et al, 2008).

2.3.2.3. Availability and Accessibility of Food in the Household

Apart from the caregivers, the physical and food home environment also have relationships with the lifestyle behavior of children. Spurrier et al (2008) studied households of 280 preschool children in Australia for the physical and nutritional characteristics of the home environment and children's physical activity, sedentary behavior and dietary patterns. The availability of healthy and unhealthy foods in the household was found to be positively correlated with the consumption of the same by the child. Rosenkranz et al (2008) has conceptualized the home food environment which has various domains including built and natural, socio-cultural, political and economic, micro-level and macro-level environments. Various determinants at each domain describe the obesogenic nature of the food environment at the household level. The web of these determinants when act at each of the domain level contributes to the development of the lifestyle behavior and body composition of the children

Vilchis-Gil et al (2015) conducted a case-control study in Mexico by examining 202 obese and 200 normal weight children. Children were assessed for their dietary patterns, physical activity and sedentary lifestyle habits. Though the consumption of obese children was less as compared to eutrophic children by 270 kcal but the type of foods available in the proximity tend to influence the dietary patterns of obese children. Also, children who were more physically active at school had a lower risk of developing obesity (OR 0.37, CI 0.16 to 0.89) as compared to children who had a sedentary behavior (OR 2.13, CI 1.20 to 3.78).

Boles et al (2013) studied the various aspects of home food environment in terms of the availability (presence of the food item in the household), accessibility (within the reach of the child-standard height of the child and an additional of 18” for arm length) and readiness to be eaten of food items in the household. The study was conducted in households with obese caregivers (n=35 obese children) and no obese caregivers (n=47 healthy weight children). The study showed that there was a significant difference in the mean number of fresh vegetables available (2.48 vs. 3.79) and accessible (2.59 vs. 3.55) in the households.

Various tools or instruments have been developed across the world to study the availability and accessibility of food items at the household level. Fulkerson et al (2008) developed a household food inventory of 190 items to assess the availability of food items in the household across 13 food categories. The authors estimated the construct (kappa statistics for the food categories ranging from 0.61 to 0.83) and criterion validity with the diet history questionnaire of the adult population, proving the validity of the instrument. Several other researchers have proven the validity of the assessment questionnaires of home food availability (Ihmels et al, 2009; Fulkerson et al, 2008; Wilson et al, 2007).

Kegler et al (2012) conducted a 6-week home based intervention to improve food and physical activity environment in ninety households following a quasi-experimental design. The families were educated regarding various components of home environment by home visits and telephonic interactions. The study resulted in the significant increase in consumption, availability and purchasing frequency of fruits and vegetables, decrease in purchase of meals and higher levels of family social support for healthy eating and increase in acquiring of physical activity equipments. The research group concluded that the women/caregivers should be targeted as gatekeepers for the intervention.

2.3.3. Community Level Determinants

2.3.3.1. Built Environment of the Neighborhood

The neighborhood characteristic features includes the seasonal variations, facilities in the neighborhood for recreation and sports, mixed land use, walking trails and sidewalks where exercise can be done, and safety from crimes in the neighborhood (Oliver et al, 2011; Gordon-Larsen et al, 2006; Jago et al, 2005; Boslaugh et al, 2004; Huston et al, 2003). An important factor in many developing countries including India is the lack of open spaces and playgrounds in schools and communities. Neighborhoods are often considered unsafe for walking and other outdoor activities.

The built environment is defined as the range of structural elements in a residential setting: housing, roads, walkways, density, transportation, networks, shops, parks and public spaces (Weich et al, 2001). Access to a safe place to play like playgrounds, recreational facilities has resulted in increased levels of physical activity (Colabianchi et al, 2009; Santos et al, 2009; Tester and Baker, 2009; Babey et al, 2008; Veugelers et al, 2008). Active commuting is also an important area under the lieu of built environment and children's health and is found to be associated with physical activity among children (Bungum et al, 2009; Hume et al, 2009; Larsen et al, 2009; Panter et al, 2009; Rosenberg et al, 2009). But the barriers to active commuting are traffic safety, pedestrian infrastructure, population density, gender, street connectedness and peer group in an area.

A recent report found that BMI is high in those residents who perceived their neighborhoods more dangerous than those who consider their community safe (Rothman et al, 2014; Saelens and Handy, 2008). Children are less likely to play outside in those community where people considered there community unsafe. In the unsafe community people don't feel safe about walking and taking part in other physical activities. Neighborhood crime plays an important role in the higher age groups; reduction in walking or physical activity, especially among adolescent women and children also are associated. Conversely, those who live in areas with more trust or "social cohesion" tend to have higher levels of physical activity.

Sari and Amaliah (2016) studied the role in built environment in the causation of undernutrition among children in Indonesia. The study showed that the road infrastructure of the village is an essential determinant of the undernutrition among children. Road infrastructure tends to affect the food security of the household since it is a medium of access to the various services available in the neighborhood (Ezeabasili et al, 2014). The authors also highlighted the lacunae of literature supporting the role of built environment and undernutrition.

Recently, evidence is available to show that various components of built environment have a bearing on the levels of physical activity but further unraveling is required to study the impact of built environment on dietary behaviors. Though there have been extensive research studies in the area of built environment and childhood obesity, the causal mechanism as to what causes what has not been clearly defined (Sallis and Glanz, 2006). Another challenge is to measure the various aspects of built environment, especially from rural Indian context. Several environmental factors that facilitate or limit physical activity have been identified. Urban designing supporting high population density, high street connectivity, and mixed land use is associated with increased physical activity; conversely, separated land use and automobile dependency reduce physical activity. Physical activity opportunities are determined outside of the traditional health sector but inter-sectoral coordination is needed for improving it.

2.3.3.2. Availability and Accessibility of Food in the Neighborhood

Environment around the neighborhood of an individual provides the opportunities for the procurement of foods in the neighborhood. Several research studies primarily with a cross-sectional study design have found that the food items which are sold outside the school premises has been associated with the children's food purchases and consumption and weight status. Glanz et al (2009) has conceptualized food environment as community nutrition environment (includes location and accessibility of food outlets), consumer nutrition environment (includes price, promotion and placement of food choices), organizational nutrition environment (access to food in other settings such as workplaces and schools) and information environment (marketing, media and advertising). Majority of literature has shown that food frequency questionnaire and brief screeners for assessing the dietary patterns have been used in majority of studies for assessing the dietary outcome in view to the environmental exposure conditions.

Engler-Stringer et al (2014) conducted a systematic review which included 22 articles to address the influence of community and consumer food environment influence on the children's diet. Literature has identified five dimensions for assessing the food environment i.e., availability, accessibility, affordability, acceptability and accommodation (Caspi et al, 2012; Charreire et al, 2010).

Availability of food items in the neighborhood has agreement with the dietary outcomes. Literature shows that individuals living in the neighborhood with the higher availability of healthy food items have a lower BMI as compared to those living in a neighborhood with a higher availability of convenience foods. But literature also shows that built environment characteristics like land use mix and population density act as moderators for influencing pedestrian walkability and thus BMI of the population. The definition of accessibility to food items has been very unclear and therefore research has shown that the access to a food store of particular type or any specific food item has not been linked with the dietary outcomes.

Caspi et al (2012) in their systematic review have reported that though there is moderate evidence available proving the hypothesis that there is a relationship between the neighborhood level food environment and dietary outcome. Dietary outcome has been measured as the daily intake of fruits and vegetables. The authors have also reported that various assessment methods used for measuring food environment did not have significant difference in the measurable outcome. There have been many studies which have done work in characterizing the food environment and work is required in linking these constructs to public health outcomes. Using multiple strategies might result in better outcomes.

Black et al (2014) developed a tool to determine the consumer nutrition environment for assessing the differences in the healthfulness of food retail stores according to their store type in the neighborhood of Hampshire, UK. The instrument designed captured various aspects of consumer nutrition environment, which includes food variety, pricing, promotion, shelf placement, store placement, type of nutrition information for twelve healthy and unhealthy food products selected on the basis of being commonly consumed in the country. The study found that the food stores located in the affluent neighborhood offer more healthy food choices. The healthfulness score of the food stores descended from the premium and large supermarkets to the discounted supermarkets.

Thornton et al (2012) conducted a study in 49 small areas of Melbourne, Australia to determine the association between fast food consumption and exposures to a variety of food store types (n=2547) within a buffer distance of 2 km. Food environment score was calculated by giving weights to food stores on a scale of +10 (healthiest) to -10 (unhealthiest) on the basis of following: availability of healthy and unhealthy food items in the store, working duration of the store as a measure of accessibility, type of food store on the basis of home delivery/take away/drive through and the prospective health benefits/risks of the store in community. The mean score of healthy food stores ranged from 8.8 (fruit and vegetable market) to 0.8 (bakery) as compared to unhealthy food stores from -1.1 (convenience food store-non fresh) to -8.3 (takeaways). The study showed that the individuals residing in the area with a large number of healthy food stores had a lower odds of frequent (OR: 0.60; 95% CI: 0.42-0.85) as well as infrequent (OR: 0.59; 95% CI: 0.36-0.96) purchase of food items as compared to the individuals who have never purchased fast food. The results also hold true for unhealthy food stored i.e., individuals residing in an area with a higher unhealthy food stores have higher odds (OR: 1.35; 95% CI: 1.00-1.82) of infrequent purchase of fast food items.

Gupta et al (2016) conducted a cross-sectional survey in low-income villages in Haryana and urban slum in Delhi to describe their food environment. They reported that the food items available in the neighborhood had high levels of saturated fats and trans-fats. Three-fourth of the snacks available in both rural and urban slum was found to be unbranded packaged snacks.

The results were in concordant to the similar study conducted by Rundle et al (2009) in New York wherein, they classified food environment as BMI healthy food stores (supermarkets/fruits and vegetable markets), BMI unhealthy food stores (fast food stores/convenience stores) and BMI intermediate within a buffer area of "805 meters" around the residential household of the individual. The results showed that the neighborhood food environment with a higher density of BMI healthy stores was significantly associated with the lower prevalence of overweight and obese individuals residing within the described buffer zone and adjusted for the neighborhood walkability features (population density, density of bus stops, percentage of commuters using public transit, land use mix, proportion of land zoned to permit commercial development. Also the median density (stores/km^2) of unhealthy BMI food stores was 64.19 as compared to that of healthy BMI stores as 10.98; though not significantly associated with the BMI.

But another study by Skidmore et al (2010) with a cross-sectional study design (n=1721) also showed that there is a higher reported intake of snack foods like sweets, chocolates and crisps in the close proximal area of convenience stores but with a very small effect size of distance to and density of food outlets in the neighborhood. Thus, sound literature is available which shows that neighborhood food environment is associated with the health or dietary outcome. And it has also been shown that the measure of built environment influences the impact of food environment measures on health outcome.

Boone-Heinonen et al (2013) estimated the interactive impacts of neighborhood level food retail features and physical activity features on the BMI of the 25 years (1986-2011) cohort (n=4,092) with 7 follow-up examinations derived from Coronary Artery Risk Development in Young Adults (CARDIA) study linked with the variations in neighborhood measures as derived using GIS at different follow-up years. The food retail (diet) and physical activity environment (activity) of the neighborhood is the illustration of the energy balance equation (energy intake = energy expenditure) at the individual level. The study has shown that when there is a concurrent increase in supermarket and commercial physical activity facility density there is reduction of 0.31 kg/m^2 of BMI in the population residing. Though, it has also been seen that the social context in terms of neighborhood poverty acts as a catalyst in these interactions between various measures.

There are various sources of food available in the community food environment for urban and rural areas respectively. For rural areas food vendors contribute to one of the major food sources available. Valdez et al (2012) conducted a cross-sectional study to determine the contribution of home based vendors (n=10) and neighborhood mobile vendors (n=13) to the rural food environment in South Texas-Mexico border. They found that over 70 per cent of the home based stores were selling sugar sweetened beverages like soda and all the mobile vendors were selling frozen snacks reflecting the availability of unhealthy food items in the rural areas. Of all the various sources of community food environment, flea markets were considered as one of the major source of food availability especially for the food insecure households. Flea markets were also identified as one of the leveraging points for the intervention for improving the availability of healthy food items in the community.

The factors in the rural neighborhood environment which increases the odds or likelihood of being overweight or obese includes poor land use, inaccessibility to facilities for physical activity within the buffer zone of 10 minutes walking distance from home, traffic congestion and safety from crime in the neighborhood, aesthetics and distance to the supermarkets for buying fruits and vegetables (Boehmer et al, 2006).

Availability of the food item in the household and its consumption as defined by the food prices is also important. When the food prices increases for any food item the likelihood of consumption of the particular food item decreases. It has been evidenced that the food environment of the community influences the dietary intakes of the population but the degree of associations is different for different measures of food environment in terms of availability, accessibility, affordability (Engler-Stringer et al, 2014). Similar inconsistency in the outcome variables have been reported from the other systematic reviews (Osei-Assibey et al, 2012).

2.3.3.3. Availability and Accessibility of Food in School

School is one of the immediate layers outside the household environment where the child spends 9-10 hours per day and is considered a place to build attitudes and behavior for future life. The school's built environment is conceptualized as containing 3 sub-domains i.e., the physical, legal and policy (Guthrie et al, 2013; Story et al, 2009). These levels function at different levels and are responsible for facilitating and inhibiting the health behavior of children by modifying the food choice made by the child. A legal component is responsible for the regulations regarding the nutritional content of food available inside the school premises. School policies regarding the food environment of the school when implemented are responsible for defining child's decision regarding a food item. For example, the total duration of free time available to the child at the time of recess moderates the child's decision regarding the purchase of food item.

The school food environment thus has a potential to have an enormous impact on the child's diet. Prior researches have shown that school contributes to a significant proportion of child's daily energy intake (19-50%). Schools have a profound impact on the lifestyle of the child. The food environment of the school is inclusive of the availability and accessibility of various types of food items in and outside school, affordability of children to buy the food items, and acceptability of the food item available. The availability and opportunity for consuming foods and beverages high in sugar or fat in schools is associated with higher BMI among children (Kubik et al, 2005). But this situation can be altered by the implementation of healthy school lunch programs (Leviton, 2008).

Wijnhoven et al (2014) assessed the school food environment score and BMI of children as per the WHO European Childhood Obesity surveillance Initiative (COSI). The data collection was done in 13 countries in two rounds. School nutrition environment score was calculated based on the availability of various food items in the school premises. BMI for age z scores were obtained for the children in the 6-9 year old age group for the children studying in the samples schools. It was found that there was a huge variability in the nutrition environment scores among different countries. The study also resulted in a statistically significant relationship between the high scores of the school nutrition environment and the BMI for age z scores.

In India, the National Programme for Nutritional Support to Primary Education began in 1995 and the Cooked Mid-Day Meal (CMDM) was introduced in the country in 2002. The scheme was started with the objectives of enhancement in the education sector by increase in the school enrolment, attendance and retention in school with the improvement in nutritional status of the child (Deodhar et al, 2010; Planning Commission, 2010). The evaluation study conducted by the Planning Commission reported that the concern of classroom hunger has been addressed by MDM with a creation of platform to bring children from all social and economic backgrounds having food together. However, it was reported that the schools had inadequate infrastructural facilities and shortage of human resource, inadequate utensils for eating food, improper channel of food grain supply. The inadequate infrastructural facilities included poor functional store rooms, cooking area, poor functional kitchen sheds, poor quality of drinking water. Human resource includes cooks, teachers or CMDM in-charge (Panning Commission, 2010). The nutritional quality of the food served to children as part of the CMDM was found to be poor in regard with the quantity served and recommended quantity (Deodhar et al, 21010).

The regulatory environment regarding food and physical activity implemented at school level is prerogative and has the ability to limit the consumption of competitive foods (the food items sold in the school apart from meals available at school; in turn competing with the regulated school meal program). Greves and Rivara (2006) assessed the implementation of nutrition policies on "competitive food" in each of the states and districts of Columbia. Of a total of 51 school districts in Columbia, 39 per cent had only adopted a nutrition policy on competitive foods varying markedly in the comprehensiveness of the policy adopted. Different component of nutrition policy included the time of day and venue of its implementation (applies only to foods/beverages sold during the school day, vending machines, cafeteria a` la carte, student stores, fundraising activities, after school fundraising or concessions, different standard sets for grade levels), content and portion size of food item (restricts food content, food portion size, sugar content of juice drinks, portion size of beverages, soda in schools) and other elements of policy beyond competitive foods (marketing of food to students, nutrition education, physical education, monitoring/compliance procedures, consequences for non-compliance, measure of physical health). In the 19 school districts where any kind of nutrition policy has been implemented; not all the recommendations of the policy were implemented.

Moore and Tapper (2008) conducted an intervention study in south-west England and south Wales in 43 schools (23 intervention schools; 20 control schools). The research study assessed the impact of fruit tuck shops on the daily food consumption of the 9-11 year children (n=1612) in intervention (n=921) and control (n=691) groups respectively. Children studying in the intervention and control schools consumed an average of 0.74 and 0.69 servings of fruit at school respectively at baseline. The school level regression models have however predicted that the tuck shops had no effect on the fruit consumption of children. But when the fruit consumption when tested with its interactions with the school policy, it was found that schools with a fruit only policy estimates of the difference in fruit consumption between intervention and control school students were 0.37 portions (95% CI: 0.11 to 0.64) greater consumption as compared to 0.14 (-0.30 to 0.58) with any food policy and 0.13 fewer consumption portions (-0.33 to 0.07) where there is no restrictions in any type of food consumed in the school.

Gonzalez-Suarez et al (2009) conducted a meta-analysis of randomized controlled trails which studied the intervention programs at school level to address obesity and overweight in school children with a mean age of six years to fourteen years. The study showed that duration of an intervention is an essential process indicator for any prevention program based at school with higher odds (OR: 0.74; 95% CI: 0.60 to 0.92) for preventing overweight and obesity.

Another school based interventional study (MARG) conducted in three cities of North India educated 40,196 children (aged 8 – 18 years), 25, 000 parents and 1500 teachers about health, nutrition, physical activity, non-communicable diseases and healthy cooking practices. The intervention resulted in a significant improvement in the knowledge and behavior scores in most children (Shah et al, 2010). Current trends and influence of school policies on physical activity in India are also not properly documented.

Lee et al (2010) conducted a pilot project of 18 months to improve the consumption of fruits and vegetables in 10 primary schools of Hong Kong among children with mean age of 9-11 years. The intervention program encompasses the comprehensive approach of community involvement, school eating regulatory environment and nutrition education program. Significant reductions were observed in the consumption of foods rich in sugar and fat (soft drinks, ice creams, desserts and confectionaries), 63.3 per cent increase in the consumption of vegetables in schools and 23.6 per cent increase in the inclusion of vegetables in the school lunch program.

2.3.3.4. Physical Activity Opportunities in School

Schools also act as important settings for the promotion of physical activity through provision of equipped playgrounds and other sports facilities, inclusion of physical education in curriculum, physical education trainers but many of the schools do not have a playground or sports facilities (Morton et al, 2015). The physical environment of the school includes the easy accessibility of the food item to the child (Chen, 2015). For example, various food access points in school like canteens, vending machines, or cafeterias are within the reach of the child in the allocated time period for recess break. The kind of engagement a child bears with the school makes it robust institutional setting for intervention studies (Shah et al, 2010). There have been many school-based intervention research studies conducted focusing at reducing the severity of obesity, affecting the activity level and nutritional intake of school children and knowledge regarding healthy behaviors.

Apart from these, the other factors integral to the school environment responsible for defining child's health include motorized commuting facilities available from home to school and school to home. However, the influence of school policies, teachers and peers on food and physical activity behavior of students has been of very little importance from the research perspective till date (Wechsler et al, 2000).

High burden of school work and academic competitiveness has further decreased the participation in sports and any other form of physical activity. This is particularly true for girls who are sedentary from school years. Recently studies have documented the reduction in play time i.e., the unstructured time during which the child is involved in physical activity has been reduced due to constraints like reduced play ground size, lack of equipments and supervisory staff and reduced play time (Ridgers et al, 2011; Thomson, 2004). For instance, Chennai has increasing rates of childhood obesity and adolescent diabetes, only 10 percent of the 457 schools in Chennai have playgrounds and only 2 per cent are equipped for games such as football, cricket, basketball and volleyball (Das et al, 2010).

Also there have been gender differences being found in schools where girls were found to be standing and boys were engaged in more vigorous physical activities (Ridgers et al, 2006; Stratton and Mullan, 2005). Play time, physical activity programs, facilities for sports activities, food facilities and psychological support from the authorities are important policy aspects that deserve systematic analysis for their impact on children's behavior towards food and physical activity. Studies indicate that school-based environmental approaches can improve the levels of physical activity (Lanningham-Foster et al, 2008) and eating behavior among children (Wechsler et al, 2000).

2.4. Prevention and Management of Overnutrition and Undernutrition

Prevention of dual burden of nutritional status must begin in childhood to reduce the burden and cost of under and over nutrition in society. In India, public health efforts so far, have been directed towards protein energy malnutrition and related nutritional deficiencies. The control of this epidemic requires a strong coordinated commitment from society and political system. This will require concerted effort of public health officials, government at all levels, schools, and the health care system. A review was conducted by Sunguya et al (2014) to determine the association between dual burden of disease as a result of nutrition transition and the presence of nutrition policies and governance mechanism placed in the low and middle income countries. The review reported that despite the co-existence of under nutrition and over nutrition together among children in low and middle income countries, only 37.9 per cent of the countries had national nutrition policies in place to address both the issues of the spectrum. And strong nutrition governance was found to be associated with the reduced prevalence of undernutrition.

The cross-sectional analysis of NFHS data by Subramanyam et al (2011) showed that economic growth of the state (measured as net state domestic product) was not associated with the risk of getting undernourish (underweight, stunting and wasting). Authors recommended for appropriate health intervention for combating undernutrition among children in India. Cooked Mid-Day Meal (CMDM) was introduced by the Government of India for improving the nutritional status of the school-going children in India with a co-objective of improving school enrolment and attendance (Deodhar et al, 2010; Planning Commission, 2010).

Despite of a high degree of increasing burden of both undernutrition and overnutrition in the country there is a lack of updated nutrition policy and poor nutrition governance in the developing countries (Paul et al, 2011). This was reiterated by the policy space analysis conducted by Thow et al (2016) in India. They showed that there are several opportunities in the current policy space of India where the integration of policies can target the dual burden of malnutrition prevalent in the country. The need of having multi-sectoral strategies has also been highlighted by Reinhardt and Fanzo (2014) considering the complex nature of the problem of chronic malnutrition.

Various intervention strategies have been used to improve the dietary habits among population and hence reduce the risk of cardiovascular and metabolic risk factors (Afshin et al, 2015). Pricing strategies (increase in subsidy/taxes, reduced prices of healthy foods) at the national level has been reported as robust tool for improving the healthy dietary behavior of the population by altering the dietary choices, made by them (Afshin et al, 2015). Local food environment around the household has been identified as a viable opportunity for improving the dietary habits of the population. However, inconsistency in the research studies conducted in the field of local food environment across the world calls the need for further investigation (Smith et al, 2013; Wang et al, 2012; Block et al, 2011; Powell et al, 2009). The intervention strategies and policy regulations at schools have shown the improvement in dietary behavior among children and healthy nutritional status as outcome (Afshin et al, 2015). Apart from these, focused mass media campaigns and marketing ban for unhealthy food products has been reported as the robust platforms for improving dietary behavior and thus contributes in reducing the risk cardiovascular risk. The intervention strategies to combat undernutrition have been reported by Bhutta et al (2013). These interventions include micronutrient supplementation, maintenance of hygiene and sanitation to prevent diarrhea and other co-morbidities and advocacy of proper feeding practices.

Therefore, considering the complex nature of the determinants of nutritional transition the comprehensive intervention strategies are required for the improvement of nutritional status at the population level (Fisberg et al, 2016). However, the effective functioning of the intervention strategies at the population level requires their inclusion in the national policies (Fisberg et al, 2016; Hawkes et al, 2015). The macroeconomic growth of the country is considered as the major policy instrument for reducing under nutrition. A global ecological study of 63 countries has reported an inverse relationship between economic growth and prevalence of under nutrition; however, these results were not replicated in the ecological study by using national data from National Family Health Survey (NFHS) (Subramanyam et al, 2011; Smith and Haddad, 2002). With the simultaneous presence of double burden of both under and over nutrition in the country requires comprehensive policies and programmes at the national level addressing both the issues in the same scenario.

Chapter 3
Methodology

CHAPTER 3
METHODOLOGY

The present research study was designed as a community based "cross-sectional" study as a part of larger research program entitled *"Foundational Work for a Brain-to-Society Diagnostics for Prevention of Childhood Obesity and its Chronic Diseases Consequences"* funded by ICMR under the ICMR-CIHR collaboration on Childhood Obesity 2009-2010. The research study aimed to assess the determinants of BMI among 6-12 year old children residing in three rural clusters of Palwal district, Haryana. These three rural clusters located at different locations in the demographic surveillance site were assumed to represent three different stages of development. For determining the determinants of BMI among children (6-12 years), a multi-level approach was used which included individual level determinants, household level determinants and community level determinants. The following determinants were assessed among the recruited children (6-12 year old): anthropometric parameters and blood pressure, lifestyle behaviour (diet, physical activity and sleep behaviour), eating pattern phenotypes, the immediate environmental exposures at household level (availability and purchase behaviour of food in the household), community level (neighbourhood built environment and community food environment) and school level (eating and physical activity environment).

3.1. Locale of Investigation

The Demographic Development and Environment Surveillance Site 'SOMAARTH DDESS' established by INCLEN for studying the issues of chronic diseases near New Delhi, in District Palwal, Haryana was selected for the study. The surveillance area includes 51 contiguous villages (approximately 2,00,000 population) from three blocks of Palwal (Hathin, Hodal and Palwal) and is circumscribed by three major roads i.e. – Delhi-Mathura National Highway (NH-2) that forms the eastern boundary of the surveillance site; Palwal–Hathin Major District Road-135, forming the western boundary; and Major District Road-132 that forms southern boundary (Figure 3.1).

The surveillance site had a demographic advantage of having a mix of populations from different religions, cultures, socio-economic and overall development status. A peripheral express highway (Kundli-Manesar-Palwal or KMP expressway) was coming up traversing through some part of the selected study site. Additionally, special economic zones (SEZ) have been declared on either side of the expressway to boost industrial growth and business. This study site was also bounded on eastern side by National Highway -2 which was one of the busiest roads in the country. The major presumption behind selecting the study site was the infrastructural / societal transformations, rapid economic, demographic, nutrition and epidemiological transition which were taking place in that area along with the surfacing of business activities and major industries, educational institutions and hospitality businesses since last three to five years (along with the NH-2 highway) (http://www.haryana.gov.in/business/ infra.html; http://agriharyana.nic.in). Agricultural land was being taken over for industrial and commercial development. Different areas in the study site were under different stages of development, depending upon their proximity to highways. With this background, 9 villages were selected for the study, which were divided into 3 clusters (3 villages in each cluster) based on the criteria of access to the highways and potential for economic development over next five years (Figure 3.1).

Cluster 1 villages (This cluster includes villages within 4kms of the proposed KMP highway): Development plans have been put in place during last few years such that eastern and western peripheral expressways (Kundali Manesar Palwal [KMP] and Kundali Ghaziabad Palwal [KGP]) shall traverse the region. Several special economic zones with new manufacturing and service industries will be establishing in this region in near future (http://www.haryana.gov.in/business/infra.html; http://agriharyana.nic.in). Villages identified as the part of this cluster were Ratipur, Durgapur and Jodhpur. The demography, culture and religion were similar across 3 villages in cluster 1 with predominantly Hindu population *(jats)*. The major occupation of the population was agricultural land owners/farmers, daily labourers, shopkeepers and private/government service.

Cluster 2 villages (This cluster includes villages on existing NH-2 Delhi-Mathura highway): Villages within one km of Mathura highway are experiencing change over a considerable period of time. Several land stretches were declared as educational, commercial and industrial lands wherein, several institutions and business establishments have already come up, in addition to private technical and management institutions. Villages identified as the part of this cluster were Sarai, Khatela and Nangla-Ahsanpur. Cluster 2 villages comprised of a mix of demography, culture and religion i.e., one village had predominantly Hindu population *(gujars)* while rest two had predominantly Muslim population *(meo).*

Cluster 3 villages (This cluster includes villages relatively far from these two highways): The south west part of the surveillance site belonged to previous Mewat region, one of the most backward areas in North India as this area was challenged with low literacy, economic status, health indices, and other development indices (HSHRC, 2013; DLHS - 4 District Fact Sheet, 2012). Villages identified as the part of this cluster were Bahin, Kot and Pahadi. In this cluster two villages had primarily Hindu population *(jats)* and one village had Muslim population.

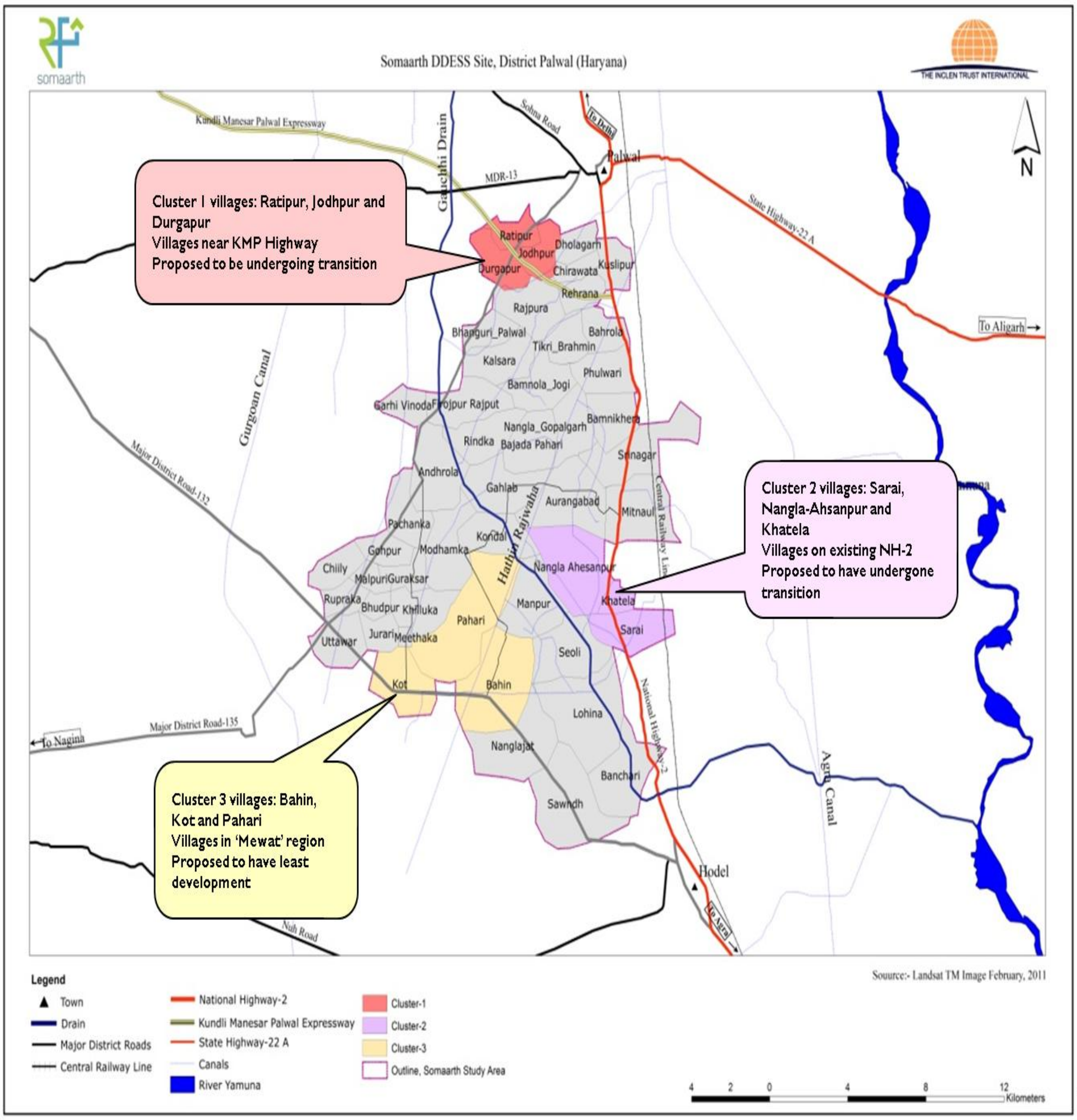


Figure 3.1: Study site

3.2. Sample

3.2.1. Sample Size

For the sample size calculation the expected proportion of overweight and obesity in the rural children was taken as 0.06 (Pandher et al, 2004), admissible error of ±2% and confidence level of 95%. On this basis, the total sample size calculated for the study was **540**. But in order to have an equal proportion of girls and boys in the age range of 6-12 years, the total sample size proposed for the study was **612** (n=612).

3.2.2. Sampling Strategy

The method of sampling used in the current study was 'Multi-stage random sampling method (cluster wise stratified sampling)'.On this basis from each of the three regions, based on line listing, 17 girls and 17 boys were randomly recruited for each one year age-band (6 age bands). Thus, from each region 204 children (102 girls and 102 boys) and 612 children in total from all the three regions were recruited for the study (Figure 3.2).

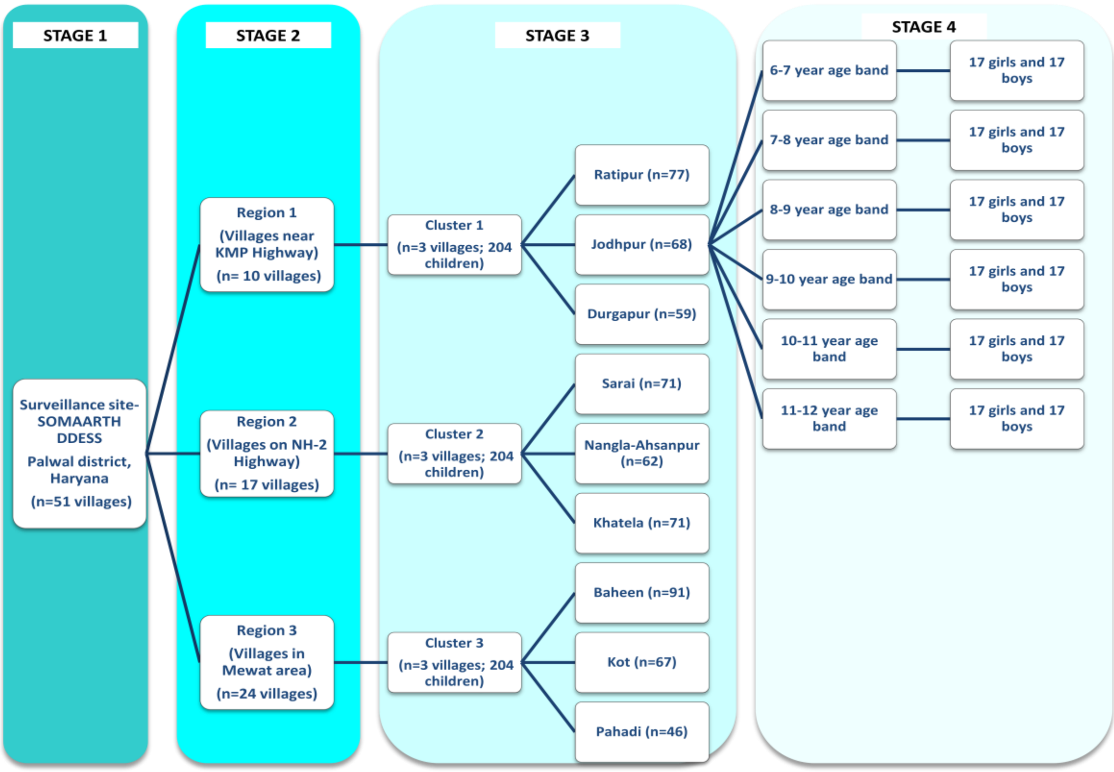


Figure 3.2: Study sampling strategy

3.2.3. Selection Criteria

Inclusion Criteria

1. The child should have completed 6 years i.e., 6 years 1 day and should not be older than 12 years i.e., 11 years 364 days.
2. Only one child from one household was recruited for the study.

Exclusion Criteria

1. Presence of medical problems that may affect body fat status (e.g. clinical oedema, hypothyroidism)
2. Known case of any chronic disorder
3. Prolonged use (more than one month) of any medication
4. Any known genetic disorders associated with obesity
5. Child with relationship up to first cousin with any of the already recruited child

3.3. Ethical Approval for the Study

The ethical clearance for the study was obtained from the Institutional Ethics Committee of Institute of Home Economics, Delhi University and Lucknow Ethics Committee (independent ethics committee of Lucknow) (Annexure 1).

3.4. Screening and Recruitment of Children (6-12 years of age)

3.4.1. Line-listing of 6-12 year old Children

A detailed census enumeration and mapping activity using GIS was done at the surveillance site for all the households in the 51 villages. The census enumeration form has been given in Annexure 2. The detailed census enumeration obtained the demographic and health related information for every household. As part of the mapping activity a GIS ID and a household ID was given to every dwelling where the household resided. Using the secondary data obtained from the census enumeration activity at the SOMAARTH demographic surveillance site, the line-listing of the 6-12 year old children in the 9 study villages was done. Line listing was done as per the following demographic characteristics including age, gender, head of the household, father's name and Household ID for all the children in the age group of 6-12 years. The line listing form used is given in Annexure 3.

3.4.2. Identification of Households and Sample Selection

After the children were line-listed, they were randomly selected based on age (divided into 6 age bands) and gender (male and female both). For the purpose of random selection, the line-listed children were given a serial number starting from 1, 2, 3,........in all 12 categories (6 age bands across both the gender i.e., male and female). These serial numbers were then used for the purpose of random selection. Random numbers were generated using web-based random number generator (www.random.org) and primary/secondary/tertiary lists were prepared for the screening of children and recruitment. The sample selected in each age band and gender was representative of the cluster and not the village.

After obtaining appropriate permissions from the head of the village ('*sarpanch*') screening was initiated in the selected villages (n=9 villages). Households of the randomly selected children in the community were identified using the household ID and the digital maps of the village prepared at the SOMAARTH surveillance site using GIS (secondary data) (Annexure 4).

The children selected randomly were screened by a medical doctor for the presence of any medical problem which may exclude them from the study. Details like school name, class and contact details were also obtained during screening for the effective planning of the data collection in the community. The screening form is given in Annexure 5. Based on the procedure adopted, the number of children recruited and screening details in each village for the study are given in Table 3.1 and 3.2.

Table 3.1: Screening of randomly selected children

S.No.	Village name	Total number of line-listed children	Total number of screened children	Reason for rejection								Total number of recruited children
				Age criteria not matched	Prolonged medication/ disorder	First cousins	Physical deformity	House locked/not found	Parents not there	Refusals	Total	
1	Ratipur	250	100	4	8	8	0	0	2	1	23	77
2	Jodhpur	263	89	3	4	9	0	3	1	1	21	68
3	Durgapur	322	92	8	6	9	0	4	4	2	33	59
Total: Cluster 1		**835**	**283**	**15**	**18**	**26**	**0**	**7**	**7**	**4**	**77**	**204**
4	Sarai	1014	121	3	6	13	1	6	5	16	50	71
5	Khatela	538	109	3	7	20	1	3	3	1	38	71
6	Nangla Ahsanpur	226	96	4	8	9	1	3	1	8	34	62
Total: Cluster 2		**1778**	**295**	**10**	**21**	**42**	**3**	**12**	**9**	**25**	**122**	**204**
7	Baheen	1030	113	5	5	1	2	3	6	0	22	91
8	Kot	628	106	5	10	6	2	2	2	12	39	67
9	Pahadi	269	59	0	5	3	1	1	1	2	13	46
Total: Cluster 3		**1927**	**455**	**10**	**20**	**10**	**5**	**6**	**9**	**14**	**74**	**204**
Total		**4540**	**885**	**35**	**59**	**78**	**8**	**25**	**25**	**43**	**273**	**612**

*The line-listing for screening and census enumeration of the surveillance site was done simultaneously for the Kot village. Therefore, the number of line-listed children is very less as compared to the total population of the village.

Table 3.2: Cluster-Age-Gender Wise Distribution of the Recruited Sample (n=612)

Age Bands	6-7 years		7-8 years		8-9 years		9-10 years		10-11 years		11-12 years		Total (6-12 year)	
Gender	**M^**	**F†**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**
Cluster 1	17	17	15	18	15	19	18	16	16	18	18	17	99	105
Cluster 2	17	17	17	17	17	17	17	17	17	17	17	17	102	102
Cluster 3	17	17	17	17	17	17	17	17	17	17	17	17	102	102
Total	**51**	**51**	**49**	**52**	**49**	**53**	**52**	**50**	**50**	**52**	**52**	**51**	**303**	**309**

^ M is male; †F is female

3.4.3. Obtaining Consent and Assigning of Study Unique Identification Number (UID) to the Recruited Child

Parents were explained the purpose of the study using the participant information sheet and a written informed consent was then obtained from the parents of the children who were eligible for the study as per the inclusion and exclusion criteria. Either of the parent gave consent for their participation in the study witnessed by a relative or a friend or any neighbour. Participation information sheet was read aloud and explained by the researcher in the households where the parents were illiterate i.e., could not read and write. Thereafter, their thumb impressions were taken as a proof of consent. Verbal assent was taken from the children also after explaining them the activities to be done in the study in the simplest language. The patient information sheet and consent forms used are given in Annexure 6.

The assistance of local person was taken wherever required for comprehending the information using local dialects. After the selection of children for the research study, they were assigned a unique identification number of 8 digits. This was done to serialize the forms and track them in the field during data collection. The first four of the 8 digits included the household number obtained from the mapping activity and the last 4 digits was the serial number given to the participant in order of the recruitment.

3.5. Research Design

The cross-sectional research study conducted among children (6-12 year old) residing in rural area of Palwal district was divided in two phases. In the first phase, the indicators defining the three rural clusters were identified using the census enumeration data from the SOMAARTH surveillance site. In the second phase, various assessments were doneon the recruited children (6-12 years old) and their households. For evaluating the determinants of BMI of children residing in the three rural clusters, assessments were conducted at three levels using various tools and techniques. Figure 3.3 explains the detailed research design of the present research study. The levels of assessment include:

- ***Individual level*** (6-12 year old child)
- ***Household level***(place where the child resides)
- ***Community level*** (neighbourhood surrounding area of the household where child resides)

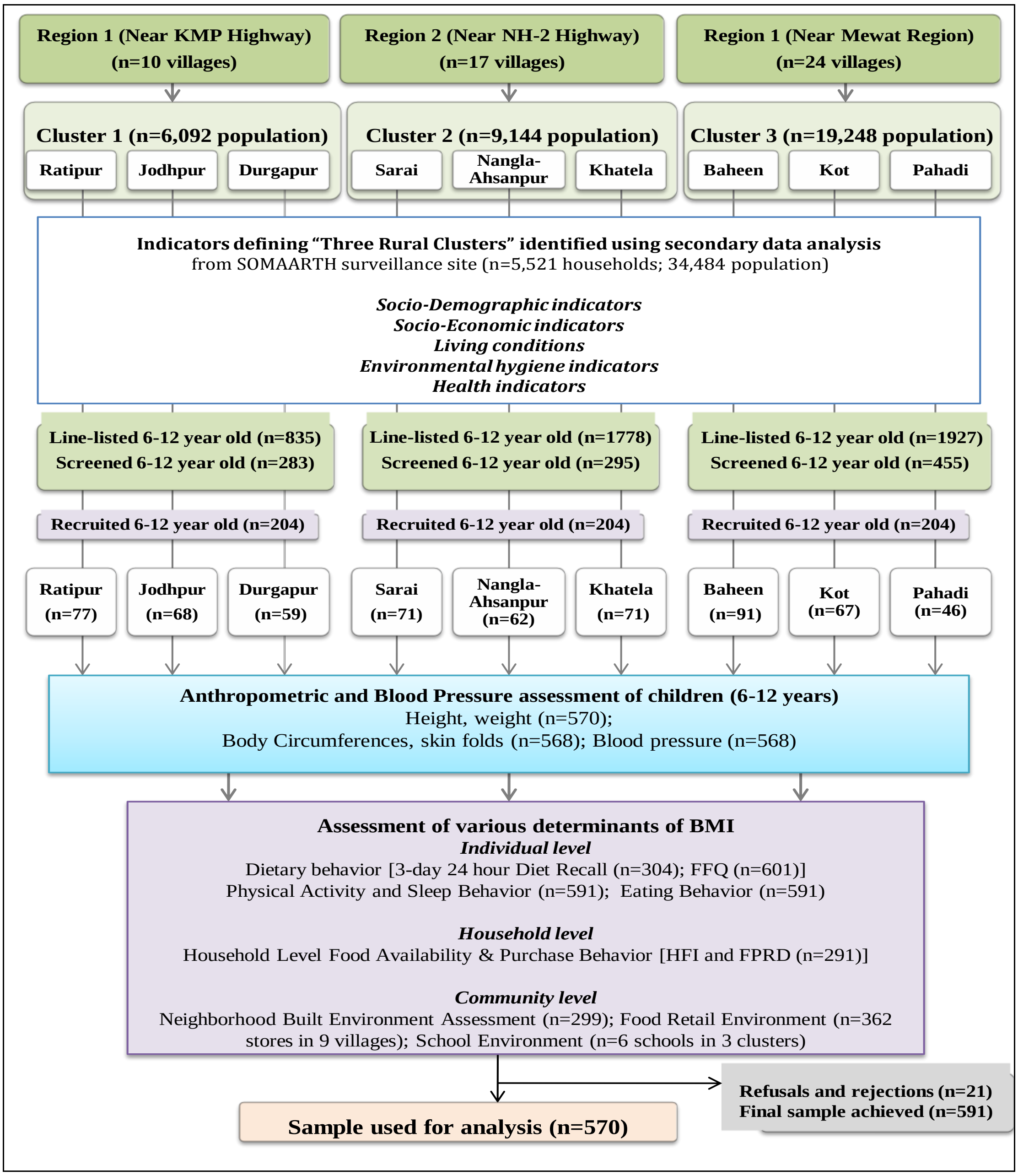


Figure 3.3: Research design

3.6. Tools and Techniques

Different methodologies were adopted for assessing the varied determinants covered in the research study. Table 3.3 describes the different tools and techniques used for the present research study and information elicited.

Table 3.3: Tools and techniques used for data collection and accomplished sample size

Tool/Instrument	Respondent	Target sample	Final sample achieved	Information elicited
Socio-Demographic and socio-economic profile of the household				
Secondary data: SOMAARTH Census enumeration data	Any family member >18 years of age	612	612	Socio-demographic profile, Socio-economic profile, Living conditions and environmental hygiene of the three rural clusters and recruited households
Anthropometric and clinical assessment				
Anthropometric measurements	Child	612	570	Underweight (WAZ), Stunting (HAZ), Body mass index (kg/m^2), Percentage body fat, Central Obesity (Waist circumference)
Clinical assessment	Child	612	570	Stage 1 and 2 Hypertension
Lifestyle behavior of the recruited child (6-12 years old)				
3-day 24 hour dietary recall	Mother/Child	306	304	Mean nutrient and food group intake of the child (6-12 years old)
Food frequency questionnaire	Mother/Child	612	601	Quantity, frequency and calorie (kcal) consumption of unhealthy foods
Physical activity-A questionnaire	Mother/Child	612	591	Met minutes of various activities done by the child; Physical Activity Level (PAL) of the child
Child Sleep Health questionnaire	Mother	612	591	Sleep duration and sleep problems faced by the child (6-12 year old)
Eating behavior of the child (6-12 year old)				
Dutch Eating Behavior Questionnaire-Children	Mother	612	591	Restraint phenotype: Restraint eating, Emotional eating, External eating
Behavioral Inhibition Scale/Behavioral Activation Scale	Mother	612	591	Sensitivity to reward phenotype: BIS; BAS (Reward responsiveness/Drive/Fun seeking)
Immediate environment exposures				
Household exposure: Food availability and purchase behavior				
Household food inventory and Food purchase record diary	Mother/father of the index child	306 (in 50% sub-sample)	291	Per capita availability of various food items in the household; Purchase patterns of the household
Neighborhood exposure				
Built environment assessment questionnaire	Mother/Father of the index child	306 (in 50% sub-sample)	299	Scores of different neighborhood built environment attributes around the recruited household
Food retail assessment	Shopkeepers in the neighborhood	As available in the community	383	Retail density in the neighborhood area; Total retail area; Average hours for which the food item is available; Store health index
School environment				
Healthy eating School environment assessment	Any School teacher	6(2 schools/ cluster)	6	Availability and accessibility of healthy food items at school level
Healthy Physical school environment assessment	Physical education trainer	6 (2 schools/ cluster)	6	Availability and accessibility of physical activity at school level

3.6.1. Socio-Demographic and Socio-Economic Profile

The census enumeration data from the SOMAARTH demographic surveillance site (n=5,521 households; 34,484 population) was used for describing the socio-demographic, socio-economic profile, living conditions, environmental hygiene and health conditions of the three rural clusters and the households of the recruited sample (6-12 year old) chosen for the study.

The socio-demographic profile includes population structure, religion, caste and category, education and occupation. The socio-economic profile of the three rural clusters was described by various economic indicators and socio-economic status. The economic indicators include the ownership of agricultural/commercial land, number of earning members in the household, ownership of bank account or BPL card, ownership of the household, household size, household construction, ownership of LPG connection/inverter and domestic animal.

The Socio-Economic Status (SES) of the rural clusters was calculated by scoring different indicators based on the scores given by standardized and validated socio-economic scales being used in rural areas (NFHS-3 2005; Pareek et al, 1964).These indicators include: education/occupation of household head, ownership of house, type of house, family type, toilet facility type, source of light, fuel used for cooking, source of drinking water, availability of separate cooking room, availability of agricultural land/any other land, social participation of family members, ownership of durable goods/livestock, any member of household have ever been out of the district/country for studies. The indicators were givenscores based on their sub-domains or presence or absence. The scores were summed for all the 19 indicators and quintiles/tertiles of the total score for all the nine villages were calculated. The socio-economic class was then categorized as five sub-categories: rich class, upper middle class, middle class, lower middle class and poor class.

The living conditions include the location of kitchen, presence of bathroom, number of people sleeping in the room, proof of smoke in the household, location of keeping domestic animal in the household, presence of animal shed in the household and place for washing clothes. The environmental hygiene conditions were described by the toilet facility in the household and the waste disposal mechanism. And lastly, the health indicators were explained by the health seeking behavior of the household in terms of the health facility preferred for treatment, lifestyle indicators, presence of chronic diseases and facility of health insurance. Similarly, socio-demographic and socio-economic profile of the recruited households was obtained.

3.6.2. Anthropometric Measurements and Indices

Anthropometric measurement and assessment of blood pressure were conducted in the household of the child, community and the school. Appropriate permissions were obtained from the school authorities where the recruited children were studying. In the villages, the anthropometric measurements for the children who were not going to the schools were done by house-to-house survey. The anthropometric measurements taken for the recruited children included weight, height, waist and hip circumference (WC and HC), mid-upper arm circumference (MUAC), skin fold thickness (triceps, biceps, sub-scapular and supra-iliac), along with blood pressure. All measurements were taken three times to reduce the intra observer error. Also, all the measurements were taken by the person of same gender as of child, i.e. female research staff measured for female child and male measured for male giving due importance to gender sensitivity. The anthropometric and blood pressure assessment form is given in Annexure 7. Researcher got trained at National Institute of Nutrition, Hyderabad for conducting anthropometric and dietary measurements among children. Post training an on-site practice of 30 days was done for getting consistency in conducting anthropometric assessment.

3.6.2.1. Weight

Weight was measured using electronic weighing machine (Model: SECA 813) with a measurement precision of up to 100 grams. For measuring the weight, the weighing machine was placed on a flat and smooth surface and the child was asked to remove shoes and accessories such as bag, any other heavy object and empty pocket. The child was made to stand on the center of the weight scale platform (as marked on the weighing machine); in erect posture with weight equally distributed on both legs. The child was then asked to get off from the machine and stand again on the machine as earlier. It was ensured that the child stands on the weighing machine only when the digital reading shows 000.000 (NIN, 2011). Weight was measured thrice and its average was obtained as final measure.

3.6.2.2. Height

Standing height is an assessment of maximum vertical size of the participant. It was measured with a portable stadiometer with a vertical backboard and a moveable headboard using (Model: SECA 213) with precision of 1mm. For measuring height, the first step was to assemble the stadiometer with the board positioned on a firm and smooth surface against a wall. In situations where flat surface against a straight (perpendicular) wall was not available, the equipment was placed against doors, trunk of the trees, doors of the cars (in case the height of the child was too short). The child was asked to remove footwear (shoes, slippers, sandals, etc) and head gear (hat, cap, hair bows, comb, ribbons, etc). In Muslim communities it was considered insensitive to seek removal of a scarf or veil, therefore the measurements of height were taken over the light fabric. Child was asked to stand with feet together, heels against the back board, knees straight, placement of feet pointed slightly outward at a 60-degree angle, straight neck (should not be tilted forward, backward or sideways), eyes looking straight, and head in Frankfurt plane. It was ensured that the heels, buttock, back of shoulder and back of head touch the stadiometer’s stand scale. The caliper was pulled down perpendicular to the scale, up to the surface of the head (NIN, 2011). All the readings were taken thrice and average was obtained as a final measure (Figure 3.4).

Weight-for-age (WAZ) and Height-for-age (HAZ) z scores were estimated using WHO growth reference standards (WHO, 2007). The WAZ are being given for children till 10 years of age and hence the prevalence of underweight has been estimated for 6-10 years of children in the present research study. The following cut-off points were used to classify children according WAZ and HAZ scores as different growth indicators (Table 3.4).

Figure 3.4: Anthropometric assessment of children

Table 3.4: Cut-off points for classifying children according to WAZ (5-10 years) and HAZ scores (5-19 years) (WHO 2007)

z-score	Weight-for-age	Height-for-age
Above +3	-	Very tall
Below -1 to above 2	Normal	Normal
Below -2	Stunted	Underweight
Below -3	Severely underweight	Severely stunted

3.6.2.3. Body Mass Index (BMI)

The BMI-for-age was categorized into thinness, normal and overweight and obese categories using IAP growth references revised in 2015 (Khadilkar et al, 2015), which have given the adult equivalent cut-offs for classifying children in overweight and obese category (Table 3.5).

BMI was calculated by following formula:

$$BMI\ (kg/m^2):\ Weight\ (Kg)\ /Height^2\ (meter^2)$$

Table 3.5: Cut-off points for classifying children (5-19 years) according to their BMI (Khadilkar et al. 2015)

Percentile	BMI-for-age
$>3^{rd}$ percentile to $\leq 10^{th}$ percentile	Thinness
$\leq 3^{rd}$ percentile	Severe thinness
$>10^{th}$ percentile to $<71^{st}$ percentile	Normal
71^{st} percentile to $<90^{th}$ percentile	Overweight
90^{th} percentile and above	Obese

3.6.2.4. Body Circumferences

Circumferences are important measurements that record the size of cross-sectional and circumferential dimensions of the body. Circumferences used alone or in combination with skin fold measurement taken at the same location, can provide indices of nutritional status and level of fat patterning. Waist circumference, hip circumference and mid upper arm circumference were measured using non-stretchable fiber glass tape (Model: SECA 201). All the circumference measurements were taken on the left side of the body, even if someone was left handed. For each circumference, tape was placed the at site perpendicular to the long axis of that part of the body. For those circumferences typically measured with the subject erect (waist, hip) the plane of the tape is also parallel to the floor. Adequate tension was applied while taking the circumference reading since the tension applied to the tape by the measurer affects the validity and reliability of the measurements (NIN, 2011). All the measurements were taken thrice and average was taken for all the three readings.

Waist (Abdominal) circumference: For measuring the waist circumference, the child was instructed to stand erect and relaxed with weight equally distributed on both feet and both feet were placed 25-30 cm apart. The child was asked to lift the clothes just high enough from navel level, to make the area visible. A point was marked just one inch (2.5cm) above the upper mark of the umbilicus (navel) using the measuring tape and the child was asked to breathe quietly. The circumference was measured around the marked point. It was ensured that the tape should not snug, and it should not be tight so as to compress tissue. Three measurements were taken and were recorded to the nearest centimeter. An indicator of central obesity for classifying children as obese or non-obese if the waist circumference is >90^{th} percentile as given by Khadilkar et al (2014) for North Indian children.

Hip circumference: The child was asked to stand erect, yet relaxed, with weight distributed equally over both feet. The hip girth was measured at the level of the maximal protrusion of the gluteal muscles (hips) and to check that level took help of scale by moving that from scapula to downwards and where it touches first at hip, takes measurement from that level. Three measurements were taken and were recorded to the nearest centimeter.

Mid-upper arm circumference: The child was asked to stand erect with the investigator standing on his/her left side. The left arm is folded at right angle at elbow, keeping close to the body. Distance from the tip of the bony prominence of shoulder (tip of acromion process) to the tip of the bony prominence of the elbow (tip of olecranon) was measured. The tape was kept in position while marking a mid-point horizontally (half the distance measured above). Then the arm was straightened and placed by the side of the body hanging loosely. Tape was passed round the arm at the mid-point such that it closely covers the arm, without applying too much of pressure or keeping it loose. The tape should not be elliptical but kept horizontal. The reading on the tape corresponding to “0” mark was recorded as the arm circumference. Three measurements were taken and were recorded to the nearest centimeter.

3.6.2.5. Skin fold thickness

Skin fold thicknesses, sometimes called “fat fold” thicknesses, are actually the thicknesses of double folds of skin and subcutaneous adipose tissue at specific sites of the body. They provide a relatively simple estimation of general fatness, and also provide information on the distribution of subcutaneous body fat. The skinfolds were measured at four sites: tricep, bicep, sub-scapular and supra-iliac using Harpenden skin fold calipers. The skin fold measurement was taken on the left side of the body even for the children who were right handed. For measuring the skinfold at any site the researcher grasped enough skin and underlying subcutaneous adipose tissue to form a distinct fold that separates from the underlying muscle with left thumb and fingers. The sides of the fold were roughly parallel.

Skinfold measurement was taken directly on skin and not through the clothing. The jaws of the caliper were applied to the skinfold held by the investigator about 0.5 to 1cm from the fingers holding the fold. It was ensured that no pressure was placed on the caliper jaws as a result of the holding of skin fold in a folded state since it would have resulted in an incorrect higher reading. Before measuring the skinfold the caliper was checked for proper moving of the display needle and it was ascertained that there was no breakage in the continuity of the arms of caliper and loosening of the caliper. It was also ensured that the caliper was not applied for a longer interval since in that case the jaws may creep or fat may compress and reading tend to be inaccurate (NIN, 2011). Measurements were taken thrice to the nearest mm and average was obtained as a final measure.

Triceps: The child was asked to remove the clothes from left arm. The triceps was measured on the same point as marked for MUAC. The child was asked to allow the arm to hang loosely at side. The skin fold was grasped from around 1 cm above the mark as described above and caliper was applied at the mark perpendicular to the grasped skin fold.

Biceps: Biceps were also measured on the midpoint of the front side of the left arm. Arm should be relaxed and in a perpendicular position before taking measurement. The skin fold was then grasped from around 0.5 to 1 cm above the mark and caliper is applied at the mark perpendicular to the grasped skin fold.

Sub-scapular skin fold: This measurement was made 1 cm below the inferior angle (tip) of the left scapula. For identification of the left medial scapular border, the child was asked to remove the clothes from back. The skinfold was grasped just below the inferior angle on a diagonal line coming down from the medial border of the scapula.

The skin fold was angled just about 45 degrees from the horizontal, going medially upward and laterally downward.

Supra-iliac skin fold: The child was asked to remove the clothes to just expose the waist area and stand comfortably. The measurement was made above iliac crest in mid-axillary line (approximately 2.5 cm above hip bone on side waist area).

3.6.2.6. Body fat percentage (%)

Body fat percentage was estimated using Slaughter and Lohman equation validated among Indian children (Slaughter and Lohman, 1988). Body fat percentage was classified as normal body fat, moderate body fat and elevated body fat using the percentiles cut-offs given by Khadgawat et al (2013) for North Indian children (Table 3.6).

$$\textbf{BF\% (boys)} = 1.21*(T+SS) - 0.008*(T+SS)^2 - 1.7$$

$$\textbf{BF\% (girls)} = 1.33*(T+SS) - 0.013*(T+SS)^2 - 2.5$$

Table 3.6: Cut-off points for classifying children according to their percentage body fat (Khadgawat et al, 2015)

Percentile cut-off	%Body fat
Below 85^{th} percentile	Normal Body fat
85^{th}-95^{th} percentile	Moderate Body fat
Above 95^{th} percentile	Elevated Body fat

3.6.3. Blood Pressure Assessment

Blood pressure (both the systolic and diastolic pressures) was recorded in the left arm using automatic blood pressure monitor (Model: Omron HEM 7080) and using a cuff of size 17-22cm. The instrument had a measurement accuracy of ±3 mm Hg. The systolic pressure is “the maximum pressure in an artery at the moment when the heart is beating and pumping”. The diastolic pressure is “the lowest pressure in an artery in the moments between beats when the heart is resting”. The digital sphygmomanometer was checked every day for the following before starting the measuring BP of children: charged batteries and properly visible digital display.

For measuring the BP of child, child was made to sit in a comfortable chair and was allowed to rest for at least five minutes. The left arm was uncovered by either removing or rolling up of cloth. The blood pressure cuff was wrapped snugly around the child's upper arm and the Velcro was fastened, so that the bottom was approximately 2.5cm above the inner bend of the subject's elbow. Child's blood pressure was recorded as the larger number over the smaller number (e.g., 150/80)--the larger number is the pressure in the arteries when the heart pumps and the smaller number is the pressure in the arteries when the heart is resting. Measurements were taken thrice at an interval of 5 minutes of the prior reading to the nearest mm and average was obtained as a final measure. The blood pressure (SBP/DBP) were being classified as normal, pre-hypertension, stage 1 & 2 hypertension using the percentile cut-offs given for the Indian children (Raj et al, 2010 and Bagga et al, 2007). The cut-offs given across the 50th height percentile were used for categorizing SBP/DBP (Table 3.7).

Table 3.7: Cut-off points for classifying children according to their Blood Pressure

Percentile cut-off	**SBP/DBP Category**
Below 90th percentile	Normal
90th-95thpercentile	Pre-hypertension
Above 95th percentile (+5mmHg)	Stage 1 Hypertension
Above 99th percentile (+5mmHg)	Stage 2 Hypertension

3.6.4. Dietary Assessment

Dietary assessment was done to understand the dietary consumption patterns of the children residing in rural community. Dietary patterns were subjected to get influenced by the foods available and accessible in the household, in the food stores situated in the neighborhood and in the schools where the child was studying. Apart from these sources the other sources of foods in rural areas included farms/fields and Mid Day Meal programme. Dietary assessment in the selected children was done using semi-quantitative FFQ and 3-day 24 hour dietary recall.

3.6.4.1. Food Frequency Questionnaire (FFQ)-Semi Quantitative

The FFQ was adopted from the one used in National Nutrition Monitoring Bureau (NNMB) surveys and was modified as per the community specific dietary patterns (NNMB, 2012). The two major components of FFQ included a list of food items and portion sizes to measure the quantity of listed food items consumed by the child. A detailed list of 110 cooked/uncooked food items was prepared after piloting the questionnaire in the community. It covered all the broad food group categories cereals, pulses, vegetables, fruits, milk and milk products, meat/fish and poultry, fat and oil, sugars and, nuts and others like sweets, accompaniments, and beverages. The consumption for the listed food items was captured over a range of reference period i.e., daily basis (once a day, twice a day or thrice a day), weekly basis (once a week, 2-3 times a week, 4-5 times a week), monthly (once 1 month, fortnightly) and yearly basis (once in 3 months, rarely). The portions sizes were validated against the reference standards using in-house designed standardization methodology. The semi-quantitative FFQ used is given in Annexure 8.

3.6.4.2. Standardization Methodology

The total sample estimated for the standardization activity was 5 per cent of the total study sample (exclusive of study sample). Therefore, for this purpose 3 household from each of the 9 villages i.e., a total of 27 households were selected randomly. The standardization activity was carried out in 2 phases i.e., field phase and laboratory phase. The field phase included the identification and measurement of commonly used serving utensils and obtaining the list of commonly consumed food items. The laboratory phase included the standardization of portion sizes in derived portion sizes (Gupta et al, 2016).

Phase 1- Field phase: In the first phase i.e. the Utensil survey**,** commonly used serving utensils were identified to derive the community specific portion sizes and the list of commonly consumed food items in the community. The quantities of the food items were then standardized as per the derived portion sizes. For this, a systematic survey was conducted in the sampled households wherein, commonly used serving utensils were identified and a one day 24-hour dietary recall was done among children in 6-12 year old age group. The dietary recall was done to understand the dietary patterns of the children, commonly consumed food items and the cooking methods used in the rural community.

The researcher conducted the household serving utensil survey and assessment of dietary patterns. The field survey took 6 days to complete. The activity was carried out in the month of March, 2012; therefore the list of food items obtained was season specific. Measurements of all the serving utensils i.e., bowl and glasses in the households were done comprehensively. Depth/diameter and volume of the utensils was measured using a measuring scale and standard cup (volume=240ml) respectively. For conducting 24-hour dietary recall in the same household, the child's mother was chosen as respondent. She was asked to recall all the food items/drinks, which were cooked in the household on the previous day. The portion of the food consumed by the child was assessed in terms of household measures. The recipe of the food items and the method of cooking were also enquired from the respondent. From the systematic survey, three portion sizes were derived based on the frequency of their use and classified as small, medium and large portion sizes to be used for the dietary assessment of the child (Gupta et al, 2016).

Portion Sizes: Depending upon the size (big or small) and type of serving utensil (SU) (bowls/glass) the data regarding the dimensions (depth and diameter) and volumes (in terms of standard cups) of the SU was pooled together. A total of 74 SUs (bowls=58; glass=16) were assessed. It was observed that bowls were preferred over glasses for even consuming liquid foods like water/tea/milk in the households of rural community. From the systematic survey, three portion sizes were identified and classified as small, medium and large size for estimating the amount/quantity of food consumed by the individual. The portion size standardization was published as an original article by the researcher as given in Annexure 9.

Phase 2-Laboratory Phase: The bowls measured in all the households showed wide variation in terms of their volumes and sizes. Food items were listed using 24-hour dietary recalls that are being consumed in the rural community and were categorized into cereal based/rice based or as curries/pulse preparation and added to the pre-existing food list. The listed food items were standardized in the derived "portion sizes (large/medium/small)" in the Foods and Nutrition Laboratory, Department of Foods and Nutrition, Institute of Home Economics, Delhi University. The food items were cooked according to the cooking methods used in the community.

Firstly, the raw ingredients (solids like cereals/pulses/vegetables and liquids like oil/water) to be used for preparation were weighed using a digital kitchen weighing scale, standardized spoons and standard measuring cup. The total weight of the raw ingredients was recorded as "uncooked weight of the dish". Using the recipes collected from the field the dish was prepared and weighed. The total weight of the cooked dish was then recorded as "cooked weight of the dish". From the cooked dish, the weight of the cooked food was estimated in the derived portion sizes using a digital weighing scale. For the preparations like Indian breads (chapatti/parantha/puri), where individual variation is found in different sizes was standardized in terms of their diameter and thickness (Gupta et al, 2016). The diameter of the chapatti was measured using the measuring scale and thickness was measured using Vernier calliper respectively (Figure 3.5).

Method of administration of FFQ: The derived portion sizes C1: 600ml, C2: 360ml and C3: 240ml after standardization were used for the dietary assessment using FFQ. Corresponding to every listed food item the respondent was asked the reference period in terms of the frequency mentioned and the approximate quantity consumed (in terms of number/cups/tsp/Tbsp). Measure of quantity varied for each food item for example, chapatti was measured in terms of numbers whereas pulse/vegetable/milk based preparations were measured in terms of cups and jam/butter/pickles were measured as tsp/TBSP (Figure 3.5).

At the end of administering FFQ, respondent was further probed for any other foods which have been consumed by her child over a given reference period.For FFQ reference period was taken as the day on which the questionnaire was administered. It helped in assessing frequency of consumption for a respective food item giving due consideration to the effect of seasonality. For example, for data collected in August, if the reference period for FFQ was 28th August'14, then the frequency of consumption of peanuts was recorded as "yearly/rarely" and if it was 4th December'14 then the frequency was "daily/weekly" (dependent on the consumption pattern of the individual) as it was consumed more frequently in winters as compared to summers.

Figure 3.5: Standardization of food items for dietary data analysis

3.6.4.3. 3-day 24-Hour Dietary Recall

A three-day 24-hour dietary recall was also conducted to assess the usual dietary intake of the children in the community. The 3-day 24 hour dietary recall was conducted in 50 per cent sub-sample. The reference period chosen for the dietary recall was 2 working days and 1 holiday to capture the fluctuations in the dietary patterns. The methodology used in the national nutritional surveys as part of NNMB was used to conduct the 24-hour dietary recall among children. The methodology obtained was equivalent to the semi-weighment method. These surveys provide population based dietary data and time trends for the same for all age groups/gender.

Figure 3.6: Dietary assessment (24 hour dietary recall and FFQ)

The methodology involved weighing of every food item (falling in all food group categories) which had been used in the preparation of food items consumed by the child in the past 24 hours. The 24- Hour Dietary Recall kit obtained from NIN, Hyderabad contains 12 standardized set of utensils/.portion sizes (C1= 1400ml; C2=1045ml; C3= 750ml; C4= 540ml; C5=350ml; C6=235ml; C7=200ml; C8=140ml; C9= 105ml; C10=82ml; C11=65ml; C12=30ml) and standard spoons (1TBSP=15ml; 1TSP=5ml; 1/2TSP=2.5ml; 1/4TSP=1.25ml)which aided in correct estimation of both the total cooked quantity of the food items as well as the quantity consumed by child (NIN, 2011). The tool used for conducting the 24 hour diet recall is given in Annexure 10.

Before starting with the actual administration of the dietary recall the respondent was identified. The person who was responsible for cooking food in the household and was familiar with the dietary pattern of the child usually the mother was selected as the respondent for dietary recall. The dietary assessment was discouraged, in case that person was not available at the time of visit by the researcher. It was preferred to have the presence of child at the time of dietary survey to enquire about the foods consumed from sources other than house. If the child was not available at the time of assessment then an effort was made by the researcher to revisit the household for obtaining any additional information. The presence of neighbors as spectators was discouraged at the time of collecting the dietary information, in order to obtain unbiased information from respondent (Figure 3.6).

The respondent was asked about the food items, which were consumed by the child in past 24 hours. All the food preparations/items which were cooked in the household and consumed by the child in past 24 hours were ***listed*** along with their raw ingredients. For the packaged foods, packaging details like brand name, quantity consumed, money spent (it acts as a proxy marker to estimate the quantity in case the subject is not able to recall the same) were enquired. Since majority of children were studying in government schools, they were entitled to food under the Mid Day Meal programme which served as both replacing meals among few children and serving as additional food among others. The detail of the same was also enquired. Few probes that were used while listing included *"any fruits eaten on previous day", "anything eaten outside or in the school/workplace or with friends", "anything eaten during the evening", "anything specific eaten before going to bed", "did somebody bring something from outside yesterday", "child's likes and dislikes in terms of food*."

After listing the food items, weighing/volume measurement of raw ingredients was done by using digital kitchen scale (SECA Kitchen Culina 852).In case a particular raw ingredient was not available in the household at the time of recall then proxy markers were used. For example; similar type of vegetable/pulse/cereal available, quantity of the food item bought from the market, money spent on buying the food item (price was then validated against quantity from market), approximate number of vegetable/fruit in terms of their size (small, medium and large-these were then standardized in-house). The dilution factor of the milk was also estimated to estimate the actual amount of milk consumed by the child.

Total cooked portions were assessed in terms of either number of pieces/volume. Measurement of total cooked portions was usually subjected to the recall bias in certain cases like if the family size of the respondent/participant was large then there were huge cooked portions so usually respondent did not remember the cooked portion or if the number of cooked preparations were more on the previous day than usual then the respondent tends to forget the cooked portion or purchased quantity. If any food item was consumed by the child at neighbor/friend/relative place and was not purchased from the market, then details of consumption were recorded.

Diet recall was not done post a wedding/ festival/ family function/ illness in the family. Seasonality acted as one of the confounders in collecting and interpreting dietary data; since consumption patterns and dietary habits change from season to season. Therefore, during the period of dietary data collection formative information was obtained from the community regarding the kind/type of dietary patterns followed during the forthcoming season. Continuous probing was done to by-pass the ambiguity of responses. Researcher faced multiple challenges in the field while collecting dietary data that included the quantification of food items consumed from fields/farms, language barrier in Mewat region and diversity in the eating patterns with the seasonal variations. Local event calendar was continuously tracked by the researcher for festivals during which the dietary intake changed significantly.

3.6.4.4. Dietary Data Analysis

Nutrient and food group intake calculation was done by DietCal software. The database of food items and their recipes was prepared for the conversions. The source of the standard database included in-house standardization, community, food labels on packaged food items, information from local vendors/shopkeepers for the food preparations like sweets and snacks, food manufacturers and schools. A total of more than 400 food items were standardized as part of the research study (Figure 3.5).

For 24-Hour Dietary Recall raw ingredients from the food consumed by the child was estimated from total cooked portions using the following formula:

Quantity of a raw ingredient consumed by the participant =
(Total quantity of the particular raw ingredient in food preparation
/Total cooked volume of food preparation)
X Total volume consumed by the participant

3.6.5. Physical Activity Assessment

Physical activity assessment was done among children to assess the pattern and type of physical activities undertaken by a child in rural areas in the age group of 6-12 years. Since children in rural areas were mostly involved in multiple unstructured activities, their physical activity assessment posed a challenge for the researcher. This happened due to lack of physical activity instructor at the school level, lack of opportunities like playground, recreation centre to play. Also, there were certain local games or cultural activities which have not been previously documented in the literature and for which Met values might not be available in international compendiums. The physical activity assessment in the present study was done by using rapid physical activity assessment questionnaire.

3.6.5.1. Rapid Physical Activity Assessment-A

The questionnaire used was the adapted version of “Quantitative history questionnaires” for assessing physical activity used by Medical Research Council (http://www.dapa-tool kit.mrc.ac.uk/physical-activity-assessment/methods/questionnaire/index.php). It aimed to capture -various activities which were incurred by the child and the time spent by the child on them in past 7 days (5 working days and 2 weekend days). The questionnaire included a list of 42 activities categorized in 4 categories i.e., outdoor, indoor, school and leisure time. It was piloted and modified as per local context. The extra activities if any incurred by the child were recorded against the specific category. The major indicators obtained from the physical activity assessment questionnaire include the frequency of different listed activities, time spent on them in minutes and sleep duration. The questionnaire used is given in Annexure 11.

3.6.5.2. Physical Activity Data Analysis

In order to assess the physical activity patterns of the child, Met Minutes were calculated using the frequency and duration (minutes) of any activity. Met value of the various activities was derived from the Compendium of Physical Activities given by Ainsworth et al (2011) and Kate Ridley et al (2008). A total of 173 activities were captured, which were being done by children (6-12 year old). Met minutes of the various activities calculated were then categorized into the following categorizes as per the characteristic of the activity: games/sports, school travel, school based activity, leisure time activities, television watching, household chores, sleep and residual time. The formula given below was used for calculating met minutes:

Met minutes = Frequency of activity X
Duration of activity (minutes) X
Met Value of the activity

Physical activity level (PAL) of the child was also estimated and was categorized as sedentary, moderately active and vigorously active. The cut-off points given by FAO/WHO/UNU (2004) were used for classifying children according to their PAL (Table 3.8).

Table 3.8: Cut-off points for classifying children according to their Physical Activity Level (PAL) (FAO/WHO/UNU, 2004)

PAL Cut-off points	Level of activity
1.40-1.69	Sedentary work
1.70-1.99	Moderate work
2.00-2.40	Heavy/Vigorous work

3.6.6. Sleep Behavior

The sleep behaviour assessment among children (6-12 year old) included sleep duration and sleep problems. This was assessed using a Child Sleep Health Questionnaire (CSHQ). CSHQ was assessed to understand the sleep duration and sleep problems faced by children in the age group of 6-12 year old (Annexure 12). The questionnaire was adopted from Owens et al (2000) and was modified as per local context. The questionnaire included 30 questions enquiring about the sleep duration and different sleep problems the child had faced in the past 7 days. The sleep problems were rated over 5-point scale (*Always* if something occurs every night, *usually* if it occurs 5 or 6 times a week, *Sometimes* if it occurs 2 to 4 times a week, *rarely* if it occurs once a week, and *Never i*f it occurs less than once a week). The sleep problems assessed include bed time resistance, sleep onset delay, sleep anxiety, night walking, parasomnias, sleep disordered breathing and daytime sleepiness. The scores of the respective sleep problem was added together to obtain the respective sleep problem score. The score ranges of different sleep problems are given in Table 3.9.

Table 3.9: Score range for different sleep problems

Sleep problems	**Range of scores**
Sleep onset delay	0-5
Sleep anxiety	0-10
Night walking	0-15
Parasomnias	0-10
Sleep disordered breathing	0-10
Daytime sleepiness	0-10

3.6.7. Eating Pattern Phenotypes

The eating pattern phenotypes were assessed to study the sensitivity to reward and restraint phenotype among children (6-12 year old). The differences in the phenotypic behavior of the children were assumed to have influence on the dietary pattern and consequently health status of the child. The restraint phenotype among children was assessed using the Dutch Eating Behavior Questionnaire, which was validated among 7-12 year old children (van Strien and Oosterveld, 2008). The questionnaire assessed three aspects of eating behavior among children including restraint eating, external eating and emotional eating. The sensitivity to reward phenotype was assessed using the Behavioral Activation Scale/Behavioral Inhibition Scale (BIS/BAS Scale). The tool was developed to assess the "aversive motivational system" (BIS) and "appetitive motivation" (BAS) among children (Carver and White, 1994).

3.6.7.1. Restraint Phenotype

The eating behaviour of the child was measured using Dutch Eating Behaviour Questionnaire-Children (van Strien et al. 2008). The assessed questionnaire was a 33-item questionnaire measured on a 3-point likert scale (no/sometimes/yes). The DEBQ-C instrument used in the study was piloted and modified as per the local context. Parent reported responses were used to classify the behaviour of the child in terms of external eating (10 items), emotional eating (13 items) and restraint eating (10 items). The score range of different eating behaviour is given in Table 3.10. The ***restraint eating scale*** included items like *"does your child try to eat less than normal if he/she gains weight?", "if your child eats a lot on one day then does he try to eat a little the next day?".* ***Emotional eating*** included items like *"does feeling frustrated/nothing to do/angry/worried/unhappy/disappointed make your child want to eat?".* ***External eating*** was captured through following *"if your child walks past an eating place (sweet shop/bakery/hotel), does he/she wish that he/she could buy something tasty?", "if your child has something delicious to eat then does he/she eat it right away?", "if your child sees other people eating then does he/she wish that he/she could also eat too?", "does your child wish that he/she could eat when he/she sees someone cooking something?'*. The scores for the respective three eating behaviours were assessed by adding the responses as obtained for respective items of the eating behaviour. The questionnaire used is given in Annexure 13.

Table 3.10: Score range for restraint phenotype as measured by Dutch Eating Behavior Questionnaire

Restraint phenotype	**Range of scores**
Restraint eating	0-30
Emotional eating	0-33
External eating	0-30

3.6.7.2. Sensitivity to Reward Phenotype

The reward to sensitivity eating pattern phenotype was measured by Behavior Inhibition scale/Behavior activation scale (BIS/BAS Scales) (Carver et al, 1994). The questionnaire was a 20-item questionnaire measuring BIS (7-items), BAS-Reward responsiveness (4-items), BAS-Drive (4-items) and BAS-fun seeking (5-items) assessed on a 5-point likert scale (strongly disagree/disagree/ somewhat neither agree or disagree/agree/strongly agree). The two different components of our behavior BIS and BAS possess different approach towards the stimuli obtained from the environment. The ***BIS components*** included statements like "*Even if something bad is about to happen to me, I rarely experience fear or nervousness', "I have very few fears when compared to my friends"*. ***BAS component*** included statements like *"When I see an opportunity for something I like, I get excited right away", "I will often do things for no other reason than that they might be fun", "I often act on the spur of the moment"*. The scores for the respective BIS/BAS levels were assessed by adding the responses as obtained for respective items. The questionnaire used is given in Annexure 14.The score range of BIS/BAS component is given in Table 3.11.

Table 3.11: Score range for sensitivity to reward phenotype as measured by BIS/BAS questionnaire

Sensitivity to reward phenotype	**Range of scores**
BIS	0-35
BAS (Total)	0-65
BAS (Drive)	0-20
BAS (Fun-seeking)	0-25
BAS (Reward responsiveness)	0-20

3.6.8. Household Exposure Assessment

Household is the immediate level of environmental exposure to which the child is exposed. Food consumption of the members of the household gets affected by the availability of food items in the household and the social norms prevailing in the household. Household food consumption is defined as "the total amount of food available for consumption in the household, generally excluding the food eaten away from home unless taken from the home" (Klaver et al, 1982). For this purpose, household food inventory and food purchase record methods were used.

3.6.8.1. Household Food Inventory (HFI)

HFI is a method, which assesses the availability of food items at the household level. In this method, all the food items (perishable and non-perishable) available in the household were measured at two time-points over a reference period of 30 days (1st day and 30th day of the reference period). The availability of 250 and more food items was measured. These food items were grouped into 13 categories. These includes cereals and millets, pulses and legumes, milk and its products, meat/fish and poultry, vegetables, fruits, fats and oils, sugar and its products, processed foods and confectionery, beverages, supplements, dry fruits and spices. Spices were only seen for their presence or absence in a household and were not measured for the available quantity. The questionnaire used is given in Annexure 15.

Standardization of the methodology for measurement: As this is a pioneering study in India, which has incorporated Household Food Inventory for the estimation of food availability at household level therefore, standardization of methodology in rural Indian context became an essential prerequisite for data collection. During standardization a number of challenges were faced.The first major challenge imposed was the diversity of the containers used for storing food items, which were usually purchased in bulk and could not be directly measured. The containers ranged from earthen pots, silos, plastic or glass bottles, stainless steel/aluminium utensils, plastic/aluminium foil bags to *kuthaliya* (made of mud and animal fodder), canister (*peepa*) and plastic/jute sacks ('*boris*'). Apart from the various types of storage containers, another major challenge was the differences in the size and shape of the utensils (Figure 3.7).

Figure 3.7a: Matka

Figure 3.7b: Sack (Bori)

Figure 3.7c: Kuthaliya

Figure 3.7d: Tank

Figure 3.7: Different shapes and sizes of food storage containers used in households in villages in Palwal district, Haryana

The shapes ranged from elliptical, barrel, cylindrical, cuboidal, and spherical. Thus, measurement of food items in the large size containers on the weighing machine would have been difficult. Thus, considering these challenges the methods for measuring the food items had to be defined for preparing the household food inventory. These measurements were then classified as direct and indirect methods of measurement.

Direct methods of measurement: Direct method included measurement of food items using a spring balance and a weighing machine.

Weighing machine: The food items weighing less than 10 kilograms were measured using weighing machine. Each time any food item was measured, the needle of the weighing machine was adjusted to “0”. If the weight of the food item was taken with the container then it was specified in the record. Calibration of the weighing machine was done on weekly basis using a digital weighing machine (SECA Kitchen Culina 852).

Spring balance: If any food item was stored in the sacks (jute/plastic) or any other kind of storage container and its weight was more than 10 kilograms then spring balance was used for weighing the particular available food item. The sack with the food item was lifted using the hook of the spring balance.

Indirect method of measurement: Indirect method of measurement included the measurement of the dimensions of the storage container using a *measuring tape*.

Measuring tape: Many food items available in the household weighed more than 10 kilograms, and they could not be measured using a weighing machine. The food items were also stored in varied dimensions of the storage containers and therefore they cannot be even measured using the spring balance. Therefore, the method adopted to capture the mass of the food items, was through using a measuring tape, wherein, the dimensions of the storage containers were measured. For example: if any food item was stored in a cuboid shaped container (canister/*peepa*), then its length, height and breadth of the container were measured. The height of the container was measured only up to the level the food item was kept in the container. Depending upon the varied shapes of the storage container, the measurements were taken accordingly. These dimensions were then converted to the volumes of the containers in which the food item was stored. Mass of the food item was calculated using the density of the respective food item (standardized in-house) and for few food items was obtained from literature.

Standardization of the density of food items: The density of various food items was required for the estimation of the quantity of food item available in terms of its weight. For its estimation, particular food item (any pulse/cereal) was taken in a measuring cylinder (standard volume: 1000mL). The measuring cylinder was filled up to the mark with the food item and was tapped twice or thrice to make space for food particles to make space for themselves and are better fit in the measuring cylinder. The weight of the food item in the measuring cylinder was measured using a digital weighing scale (SECA Kitchen Culina 852). Three readings were taken for every food item and then the mean was taken as the final reading. The final reading was divided by the standard volume of the measuring cylinder (up to which the food item was taken). The calculated values were used as the density of the respective food item and are given in Table 3.12.

Table 3.12: Densities of various food items

S.No.	Category/Food Item	Density (g/mL)	Reference
A.	**Cereals**		
1	Wheat	0.83	Standardized in-house
2	Wheat flour	0.65	
3	Sorghum (Jowar)	0.72	
4	Pearl Millet (Bajra)	0.83	
5	Rice	0.90	
6	Semolina (Suji)	0.74	
7	Refined Flour (Maida)	0.70	
B.	**Pulses**		
1	Dehusked Moong dal	0.81	Standardized in-house
2	Whole moong dal	0.92	
3	Dehusked urad dal	0.84	
4	Whole urad dal	0.83	
5	Arhar dal	0.87	
6	Chana dal	0.81	
7	Dehusked masoor dal	0.89	
8	Chole	0.82	
9	Black chana	0.82	
10	Soyabean nuggets	0.20	
11	Besan	0.58	
C.	**Milk**		
1	Buffalo milk (with 6.4%fat and 10.2 % solid non-fat)	1.034 g/ml	Ahmad et al (2013)
D.	**Sugars**		
1	Sugar	0.96	Standardized in-house
2	Khand	0.86	
E.	**Fats/Oils**		
1	Desi ghee	0.9109	Changade et al (2006)
2	Vegetable refined oil (sunflower)- at 30 degree celsius	0.9114	Esteban et al (2012)
3	Vegetable refined oil (soyabean)-at 30 degree celsius	0.9127	Esteban et al (2012)
4	Vegetable refined oil (soyabean)-at 25 degree celsius	0.914-0.918	Noureddini et al (1992)

Considerations made while doing HFI

- If any food item was available in the farms/fields then only the amount, which was consumed by the family members, was recorded.
- The quantity of available food item, which was consumed before the assessment was started, was excluded.
- Consumption of wheat grain/wheat flour by the livestock like hens, baby buffalo/cow etc.in the household was excluded from the total consumption.
- If there was any kind of celebration/event in the family then assessment was not done during that period.

3.6.8.2. Household Food Purchase Record Diary (FPRD)

FPRD was a booklet given to the household for the defined reference period (30 days) and the respondent was asked to record the food purchases daily along with their quantity and the money spent on them. Source of food item including farm/field, given or brought by any relative/neighbour, purchased from a food store/school canteen, received as *prasad* from temple, purchased through Public Distribution System (PDS), consumed outside the house in any event or any other house were also recorded. Same reference period was used for the assessment of household food inventory and food purchase record in order to triangulate the consumption data with the purchases made by them. Apart from that, the households were also asked to record if any donations were made by them during the reference period. Compliance visits were made every alternate day by the researchers to ensure that all the purchases were recorded in the diary.

For avoiding any kind of loss of the data (if diary was torn by the family members, or any other kind of harm has been done to it during the reference period) two diaries were maintained for the purchase record. One diary was given to the family members and the other remained with the researcher. Both the diaries were completed on every compliance visit to the household. In case the parents of the respective households were found to be illiterate then in that household either child was given the responsibility for completing the details in the booklet or the researcher herself completed the details at the time of compliance visit. The questionnaire used is given in Annexure 16.

3.6.8.3. Household Food Availability and Expenditure-Data Analysis

The data of the household food inventory (HFI) and food purchase record diary (FPRD) was processed to calculate the per capita availability and expenditure of food item at the household level. The measurements done using indirect methods i.e., measuring tape in the form of containers dimensions, following formula was used to calculate the weight of the food item using the standardized densities of the food items.

> **Weight of the food item =**
> Volume of the food item (ml) X Density of the food item (g/ml)

After calculating the weight of all the food items, the quantities of all the food items and per capita availability were obtained using the following formula:

> **Quantity of food item available in 30 days =**
> [{Qty of food item at baseline + (qty of food item purchased on D1 +D2+……+D30)} – Qty of food item at endline] –
> Qty of food item consumed by livestock (if applicable)

> **Per capita availability of any food item =**
> Quantity of food item available in 30 days
> /number of family members

The per capita expenditure was calculated similarly by summing the expenditure made on the food item during the reference period and dividing it by the number of family members. The cost of expenditure for the food items which were self-produced, procured from farms/field or given by neighbours and relatives was imputed as per the standard food prices of the food items (NSSO, 2011). The prices of different food items as captured in study data were used for imputing the standard cost of the food items, wherever, the cost was not mentioned or food was procured from the farms/field, received as gifts from neighbour/relative.

3.6.9. Neighbourhood Exposure

Neighborhood environment is the layer of external stimuli around the household where the child is residing. It provides various opportunities and threats for healthy food eating choices and active physical activity. The built environment structure and the food stores in the neighborhood of a child act as the facilitators and barriers in assessing the dietary consumption and physical activity expenditure pattern of the child.

3.6.9.1. Built Environment Assessment

For designing the quantitative assessment tool for understanding the built environment structure in the neighborhood of the reference household in the rural areas, in-depth interviews (IDIs) were done with the "key informants" from the sampled villages. The interview guide used is given in Annexure17. Key informants included *nambardars, panchayat* members*, chowkidaar and patwari*. Prior appointments were taken from them before conducting the interview.

The in-depth interviews were then transcribed and free listing of responses was done. The process of translation was by-passed for retaining the soul of the interview with respect to its language. The responses were then coded and categorized as per different domains covered in the "Built environment assessment tool (BEAT)" developed by CDC (http://www.cdc.gov/nccdphp/dch/built-environment-assessment/).

BEAT assessed the characteristics of built environment, which affect "health" by means of physical activity (walking/bicycling). The responses in the standardized questionnaire "BEAT" were contextually modified as obtained from the IDIs with the key informants and locally piloted. The built environment assessment was done in 50 per cent sub-sample of the total sample. For the assessment of built environment, the neighborhood of a household where the child is living was defined as the distance of "*500 meters*" around the household. The perception of built environment requires a basic level of knowledge to understand the same. The criterion for the respondent was any person who was living in the house, was above 18 years of age and should have possessed a basic educational qualification. The neighborhood built environment questionnaire used for the assessment is given in Annexure 18.

Different domains which were covered in the questionnaire included the following: Density and land use (3-items), pedestrian infrastructure (9-items), bicycling infrastructure (8-items), roads and parking (9-items), trails and other modes (4-items), transit (5-items), safety (5-items), aesthetics and character (6-items), proximity to services (4-items) and planning and engagement (4-items). The score range of different attributes is given in Table 3.13.

Table 3.13: Score range for different attributes of built environment

Built environment domain	Range of scores
Density and land use	0-9
Pedestrian infrastructure	0-27
Bicycling infrastructure	0-24
Roads and parking	0-27
Trails and other modes	0-12
Transit	0-15
Safety	0-15
Aesthetics and character	0-18
Proximity to services	0-12
Planning and engagement	0-12
Total Built environment score	0-171

The questionnaire had a total of 57 items with 3-point scored options. The household's neighborhood/built environment were further categorized on the basis of the total score obtained for the household. A score of "0" was given to the question which was either "not applicable" in regard to the reference household or the respondent "was not informed/does not know" about it. Along with the questionnaire photograph cards were also used along with the questionnaire so that respondent can understand the built environment construct. The scores of all the items was summed together to obtain a score of an active built environment. The photo cards are given in Annexure 19.

3.6.9.2. Community Food Environment

The determinants governing the neighborhood food retail environment was not only the urban–rural linkage that defines the availability and accessibility of various food items but also affordability (as per the SES of the community) and the acceptability of the food items among the individuals living in the community. The type of food retail in the neighborhood was presumed to have a direct relationship with the per capita availability and consumption of the food items in the household. For measuring the food retail exposure of children, complete enumeration of the all the food stores was done in all the 9 villages from which the study sample was drawn.

Brief assessment of all the food stores was done with a major focus on capturing various characteristics of the food business unit in terms of 2P's of marketing i.e., product (type of food products available in different food categories) and place (location of the business unit).Availability of food products was captured for the food items in the same categories as used for the dietary intake assessment of the individual. This exercise of listing the food stores was done to identify and categorize the kind of food retail environment flourishing in the community.

The characterization of food stores was done by researcher using a quantitative short survey which informed about the location of the business unit/food store (on the highway/on the main village road/on the streets/on the lanes), operational duration (hours) of the business unit), type of business unit (fixed/mobile/semi-fixed unit), type of business (retail/wholesale), customer approachability of food items (counter based/walk-in store), total area of the food store, approximate valuation of the food store, and the availability of different food items in the store. Food item availability was captured under various food categories including cereals, pulses, milk and its products, fruits, vegetables, meat/fish/poultry, fats and oils, sugars, dry fruits, supplements, sweets, salty snacks, beverages, confectionary or sweet snacks, ready to eat snacks/meals, bakery products, preserved food items and tobacco/*beedi/paan.* The food store assessment and mapping form used is given in Annexure 20.The availability and accessibility of the food items in the neighborhood was assessed by calculating the following indicators as given in Table 3.14.

Table 3.14: Indicators for assessing community food environment

Indicator	Purpose	Definition
Store health index	Availability	The probability of the availability of healthy food items in a store over the unhealthy food items
Retail density	Availability	Total retail area available per 1000 population
Duration (hours)	Accessibility	Average duration for which food items is available
Retail Space (sq. ft.)	Availability	Total retail area of the village/cluster

3.6.10. School Eating and Physical Activity Environment

School is one of the very important layers of the environment wherein, the child spends almost 7-8 hours i.e., one-third of a day. This level of environment provides strong influence on the consumption pattern and physical activity behaviour of the child through the infrastructure/facilities provided and the peer interaction. For assessing the school environment two schools were chosen from every sampled cluster i.e., one government school and one private school. Every school (n=6) selected was assessed for its physical activity and healthy eating access to children. The school health survey component of SHAPES (School Health Action Planning Evaluation survey) and an In-depth interview (IDI) were used for the assessment of school environment (https://uwaterloo.ca/propel/program-areas/healthy-living/shapes-school-health-action-planning-and-evaluation-system). The stakeholders chosen for the SHAPES were the physical activity instructor for the physical activity component and canteen/Mid-Day Meal (MDM)/food in-charge for the healthy eating component.

The first component assessed the SWOT analysis of the physical activity at the school level. It includes the following: students' access to secure, clean physical activity infrastructures within the school, during and off school hours, students' access to active transportation and the extent to which schools promote it, students' access to after-school (intramural, interschool or academic excellence programs) physical exercise programs, the accessibility, safety of physical education and the extent to which they generate physical activity opportunities, the extent to which schools empower community social environment, collaborate with community partners. The SHAPES questionnaire for physical activity environment assessment is given in Annexure 21.

The second component assessed the healthy eating at school level including the following: students' access to healthy eating options including fruits and vegetables within the school context and to what extent schools promotes them, the access to school nutrition programs and to what extent the schools promote healthy eating education and awareness. Both the components were locally piloted and modified contextually. The SHAPES questionnaire for school eating environment assessment is given in Annexure 22.

3.7. Data Cleaning, Processing and Statistical Analysis

The data entry for all the domains was done twice in the SOMAARTH surveillance software followed by a post-hoc quality check mechanism. The data was further cleaned in MS-Excel and managed/analysed in STATA Data analysis and statistical software v12.0 (special edition). The codebooks for all the quantitative questionnaires were standardized after free listing of all the responses (if required). The data was then cleaned for any missing values and inconsistencies matching the codes in the codebook. After the raw data was cleaned, the data was further processed and managed to derive datasets regarding different variables required for the statistical analysis.

The distributions of the variables for the data from nearly all the domains were found to be skewed. Thus, the logarithmic or square root transformations were done in order to establish normality of the data. Despite age and gender differences in the data, only cluster level stratification was done for the bi-variate analysis due to the less sample size in each age, gender and cluster specific strata. Considering the skewness of the data, the data is presented median, inter-quartile range and 95% Confidence Interval for all the variables.

The statistical tests employed for the bi-variate statistical analysis include: Chi-Square/Fisher's Exact test (categorical variable) and Two-Group Mean-Comparison test/Wilcoxon rank sum test or One-way ANOVA/Kruskal Wallis and Post-Hoc Tukey's/ Dunn's test (continuous variable). The odds ratio, 95% CI and p-value were also assessed for the categorical variables as a part of bi-variate analysis. The level of significance was taken as p-value (<0.05). For assessing the associations, predictors of between various dependent variables and interactions between various independent variables with the dependent variable, Multivariable logistic regression analysis and Step-wise Multivariable logistic regression were done.

Chapter 4
Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

The present research study was conducted across nine villages spread in three rural clusters of Palwal district, Haryana. These rural clusters were selected from the SOMAARTH DDESS developed by INCLEN. A sample of 612 children (6-12 year old) and their households were recruited from the nine villages to assess their lifestyle behavior (dietary behavior, physical activity and sleep behavior), eating pattern phenotypes (sensitivity to reward and restraint phenotype), immediate environmental exposures (household food availability and purchase behavior, community level built environment and food environment and school level eating and physical activity environment) and anthropometric/clinical assessment (height, weight, circumferences, skin fold thickness and blood pressure).

4.1 Description of the Three Rural Clusters

The three rural clusters with nine villages were selected based on the criteria of their access to highways and the degree of development they were undergoing. The clusters included a total of 5,521 households with a population of 34,484 in these nine villages. The first cluster was selected near to the Kundli-Manesar-Palwal highway (KMP); it was assumed that this region is undergoing development due to the developing highway. The second cluster was selected near to the NH-2 highway; where it was assumed that the cluster had already undergone some degree of development. The third cluster was chosen near the Nuh-Hodal state highway in Mewat region and was assumed to have undergone lesser degree of development. The second cluster was denser in terms of population per square kilometer as compared to the first and third cluster (Table 4.1 and Figure 4.1). As more developed regions generally have higher population density (World Bank, 2014), the three clusters represented different degree of development as primarily evident from their population density.

Table 4.1: Population density (persons/sq. km.) of the three rural clusters of SOMAARTH DDESS in Palwal district, Haryana*

Village	Population	Area (sq. km.)^	Density (persons/sq.km.)
Cluster 1 (n=3 villages)	6092	8.3	734.0
Cluster 2 (n=3 villages)	9144	6.2	1474.8
Cluster 3 (n=3 villages)	19248	32.8	586.8
Total (n=9 villages)	**34, 484**	**47.3**	**729.0**

*Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region^ Area of the villages was determined by GIS mapping of the area by INCLEN team

According to Census (2011), the population density of Palwal district was 762 persons/sq.km. as compared to the mean of 729 persons/sq.km. of the total nine villages selected for the study.

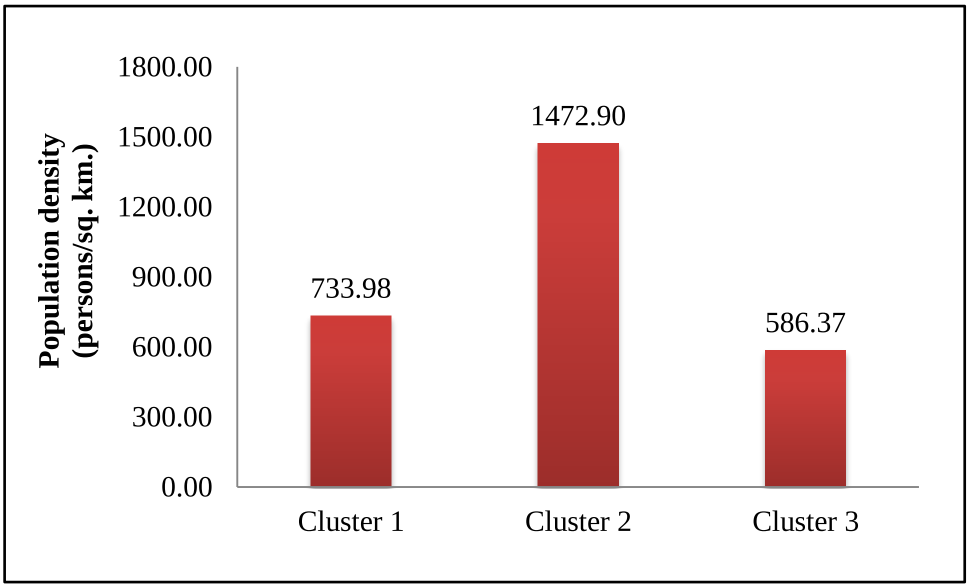


Figure 4.1: Population density (persons/sq. km.) of three rural clusters

4.1.1. Socio-Demographic Profile of Three Clusters

The socio-demographic profile of the population in the nine villages selected for the research study across three clusters is described in Table 4.2. The third cluster had the maximum population (over 19,000). The total population of nine villages was nearly

35,000 out of which 52.4 percent were males and 47.6 percent were females. Male-female ration across three clusters was similar. The sex ratio of the area under study was 907 females per thousand males which was better than the sex ratio of the Palwal district (both rural and urban area) i.e., 880 females per 1000 males (Census, 2011). The total population in the age range of 6-12 years was different across three rural clusters with the least proportions in the first cluster (males-14.7% and females-13.6%). In contrast, the productive population of the age range of 19-45 years was highest in the first cluster (42%) as compared to second (32.5%) and third (35.0%) clusters.

Cumulatively, Hindu population was higher in the area (56.2%) as compared to that of Muslims (43.6%). However, the Muslim population predominated in the second cluster (74.9%) as compared to the first (1.8%) and third (44.1%) cluster respectively. Over, 70 per cent of the population belonged to scheduled caste and other backward classes (SC/OBC) and 28 per cent of the population belonged to other castes and forward communities. The median size of a household was six family members across the three rural clusters.

Table 4.2: Distribution of population according to the socio-demographic attributes in three rural clusters (n=34,484)*

Indicator	Cluster 1 (n=6,092)	Cluster 2 (n=9,144)	Cluster 3 (n=19,248)	Total (n=34,484)
Demographic distribution				
Total population	6092 (17.7)	9144 (26.5)	19248 (55.8)	34484 (100.0)
Total males	3213 (52.7)	4780 (52.3)	10082 (52.4)	18075 (52.4)
6-12 years males	471 (14.7)	1013 (21.2)	1954 (19.4)	3438 (19.0)
Total females	2879 (47.3)	4364 (47.7)	9166 (47.6)	16409 (47.6)
6-12 years females	391 (13.6)	926 (21.2)	1756 (19.2)	3073 (18.7)
Religion				
Hindu	1072 (98.2)	350 (24.9)	1683 (55.7)	3105 (56.2)
Muslim	20 (1.8)	1052 (74.9)	1334 (44.1)	2406 (43.6)
Christian	0 (0.0)	3 (0.2)	7 (0.2)	0 (0.2)
Category				
SC/ST/OBC**	663 (60.7)	1380 (98.2)	1929 (63.8)	3972 (71.9)
General	429 (39.3)	25 (1.8)	1095 (36.2)	1549 (28.1)

*Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
**SC/ST/OBC is Schedules Caste/Schedules Tribe/Other Backward Class; there were almost negligible tribal population in the area.
Figures in parenthesis denote percentages

There were differences in the educational profile of males and females in the three rural clusters (Table 4.3 and 4.4). The educational level of women was significantly less as compared to men; the educational level of women was particularly low in cluster 2 and 3. Overall the educational level in the first cluster was better than that in the second and third cluster. The education level in the 6-18 years of age group showed a trend towards improvement particularly for the girls as compared to their adult counterparts. The proportion of population with higher education (graduate/post graduate /professional degree) among both males and females was higher in the first cluster as compared to the other two clusters. Overall, the literacy rate was around 66.7 per cent in the three clusters. According to Census (2011), there was an increase in the literacy rate (7+years of age) of the population residing in the Palwal district from 59.2 per cent in 2001 to 69.3 per cent in 2011.

Table 4.3: Distribution of the male population in three rural clusters according to their education profile *

Education category	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Total**
6-18 years				
	(n=1,336)	**(n=2,671)**	**(n=5,111)**	**(n=9,118)**
Illiterate/can sign or read	311 (23.3)	993 (37.2)	1721 (33.7)	3025 (33.2)
Primary schooling	409 (30.6)	846 (31.7)	1519 (29.7)	2774 (30.4)
Middle schooling	305 (22.8)	524 (19.6)	1080 (21.1)	1909 (20.9)
Higher secondary schooling	300 (22.5)	305 (11.4)	750 (14.7)	1355 (14.9)
Graduate/Post graduate/ professional degree	11 (0.8)	3 (0.1)	41 (0.8)	55 (0.6)
>18 years				
	(n=1,877)	**(n=2,109)**	**(n=4,971)**	**(n=8,957)**
Illiterate/can sign or read	202 (10.8)	761 (36.1)	1575 (31.7)	2538 (28.3)
Primary schooling	52 (2.8)	118 (5.6)	170 (3.4)	340 (3.8)
Middle schooling	513 (27.3)	550 (26.1)	1073 (21.6)	2136 (23.9)
Higher secondary schooling	796 (42.4)	563 (26.7)	1543 (31.0)	290 (32.4)
Graduate/Post graduate/ professional degree	314 (16.7)	117 (5.6)	610 (12.3)	1041 (11.6)

* Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
Figures in parenthesis denote percentages

Table 4.4: Distribution of the female population according to their education profile in three rural clusters*

Education category	Cluster 1	Cluster 2	Cluster 3	Total
6-18 years				
	(n=1,149)	**(n=2,378)**	**(n=4,650)**	**(n=8,177)**
Illiterate/can sign or read	312 (27.2)	1138 (47.9)	2180 (46.9)	3630 (44.4)
Primary schooling	322 (28.0)	760 (32.0)	1265 (27.2)	2347 (28.7)
Middle schooling	284 (24.7)	368 (15.5)	757 (16.3)	1409 (17.2)
Higher secondary schooling	226 (19.7)	110 (4.6)	435 (9.4)	771 (9.4)
Graduate/Post graduate/ professional degree	5 (0.4)	2 (0.1)	13 (0.3)	20 (0.2)
>18 years				
	(n=1,730)	**(n=1,985)**	**(n=4,516)**	**(n=8,231)**
Illiterate/can sign or read	887 (51.3)	1582 (79.7)	3494 (77.4)	5963 (72.5)
Primary schooling	40 (2.3)	55 (2.8)	64 (1.4)	159 (1.9)
Middle schooling	366 (21.2)	230 (11.6)	457 (10.1)	1053 (12.8)
Higher secondary schooling	324 (18.7)	99 (5.0)	335 (7.4)	758 (9.2)
Graduate/Post graduate/ professional degree	113 (6.5)	19 (1.0)	166 (3.7)	298 (3.6)

*Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
Figures in parenthesis denote percentages

There were differences in the occupation profile of the population (both males and females) across the three clusters (Table 4.5 and 4.6).

Table 4.5: Distribution of the male population (>18 years) in three rural clusters according to their occupation profile *

Occupation profile	Cluster 1 (n=1,877)	Cluster 2 (n=2,109)	Cluster 3 (n=4,971)	Total (n=8,957)
Student/unemployed	320 (17.1)	239 (11.3)	790 (15.9)	1349 (15.1)
Labor/domestic work	339 (18.1)	587 (27.8)	1230 (24.7)	2156 (24.1)
Skilled labor	11 (0.6)	6 (0.3)	14 (0.3)	31 (0.4)
Business	51 (2.7)	63 (3.0)	127 (2.6)	241 (2.7)
Professional	98 (5.2)	190 (9.0)	270 (5.4)	558 (6.2)
Agriculture	271 (14.4)	381 (18.1)	1112 (22.4)	1764 (19.7)
Govt./Pvt.Job	787 (41.9)	643 (30.5)	1428 (28.7)	2858 (31.9)

* Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
Figures in parenthesis denote percentages

In contrast to the usual impression, only one fifth of the male population mentioned agriculture as the primary occupation; almost two-fifth of the adult males were engaged in some government or private job or in a profession. Cluster one had larger proportion of persons in regular job and professional activities with lesser proportion as unskilled laborer and agriculturist compared to remaining two clusters (Table 4.5).

Table 4.6: Distribution of the female population (>18 years) in three rural clusters according to their occupation profile *

Occupation profile	Cluster 1 (n=1,730)	Cluster 2 (n=1,985)	Cluster 3 (n=4,516)	Total (n=8,231)
Student/housewife	1356 (78.4)	1650 (83.1)	3761 (83.3)	6767 (82.2)
Labor/domestic work	47 (2.7)	63 (3.2)	104 (2.3)	214 (2.6)
Skilled labor	5 (0.3)	0 (0.0)	0 (0.0)	5 (0.1)
Business	3 (0.2)	0 (0.0)	4 (0.1)	7 (0.1)
Professional	7 (0.4)	5 (0.3)	1 (0.0)	13 (0.2)
Agriculture	1 (0.1)	6 (0.3)	7 (0.2)	14 (0.2)
Govt./Pvt. job	311 (18.0)	261 (13.2)	639 (14.2)	1211 (14.7)

* Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
Figures in parenthesis denote percentages

The majority of the female population (>18 years) mentioned household work as their primary task across all three clusters (82.2%). The household work of a female in a rural area includes the livestock related activities, agricultural activities, cooking food, and other household chores including care of their children, household members and themselves. Non-formal interactions by the researcher with the men and women of the area during data collection indicated that women contributed significantly to the agricultural activities of the household and men have started looking for regular jobs and other professions for supplementing their income. According to literature, there is significant shift in the tasks of the rural women in recent years, and feminization of the farm sector has taken place (Behera and Behera, 2013). However, when we ask about the occupation of women, it is mentioned as household (Table 4.6). The feminization of agriculture was further confirmed by the observation that only about 20 per cent men were engaged in farming and almost 40 per cent of the adult male population of the area was in regular jobs or other professions. Similar, to male population the employment in government/private sector seems to be increasing among females also with 18 per cent of the females in first cluster, 13.2 per cent in second cluster and 14.2 per cent in third cluster respectively being in government/private service (Table 4.6).

Thus, the three rural clusters of Palwal district under study were different in terms of the population density, the demographic structure, and distribution of population according to religion, social status and education and occupation profile of both males and females.

4.1.2. Socio-Economic Profile of Three Rural Clusters

This section discusses the socio-economic profile of the three rural clusters as defined by various economic indicators. We had two parameters: per-capita income and SES categorization according to the scores of 19 indicators. The socio-economic class was estimated by adding the scores given to different sub-domains of 19 indicators. As described in the methodology, these indicators include the demographic (education/ occupation of household head, family typology), household characteristics (household ownership, household construction, toilet facility, source of light, fuel used for cooking, source of drinking water, availability of kitchen), economic (availability of land, ownership of assets and livestock) and social (social status in the community) characteristics of the households. Both methods indicated that the first cluster was richer and with significantly higher proportion of households in high and upper middle class categories compared to that of the second and third clusters (Table 4.7 and Table 4.8).

Table 4.7: Total annual and per capita income (INR) of the households in the three rural clusters (Median, IQR and 95% CI)*

Indicator	Cluster 1 (n=1092)		Cluster 2 (n=1405)		Cluster 3 (n=3024)		Total (n=5521)	
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI
Total annual income (INR)#	84000 (54500, 164000)[ac]	80000-86000	70000 (48000, 116000)[ab]	70000-72000	64100 (40000, 120000)[cb]	60000-68000	70000 (45000, 126000)	70000-72000
Per capita annual income (INR)	16800 (10000, 34550)[ac]	15839.5-18333.3	12000 (7142.9, 21666.7)[a]	11500-12500	12000 (6527.8, 23000)[c]	11766.2-12000	12500 (7200, 24500)	12000-13330.9

* Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
#Total annual income is inclusive of income from all sources (service/agriculture/pension/business/rent/any other source)
Same superscripts (a/c) represents the significant differences ($p<0.000$) as tested by Kruskal Wallis and post-hoc Dunn's test.
Same superscripts (b) represents the significant differences ($p<0.01$) as Kruskal Wallis and post-hoc Dunn's test

The median reported total annual income (income from all sources-service/agriculture/ pension/business/rent/any other source) of the household in the first cluster was 14,000 INR more as compared to other two clusters.

Table 4.8: Distribution of the households in three rural clusters according to the Socio-economic status (SES) class of the household and other economic indicators[#*]

Indicators	Cluster 1 (n=1092)	Cluster 2 (n=1405)	Cluster 3 (n=3024)	Total (n=5521)	p-value**
Socio-economic status					
Poor class	124 (11.4)	283 (20.1)	701 (23.2)	1108 (20.1)	0.000
Lower middle class	192 (17.6)	379 (27.0)	687 (22.7)	1258 (22.8)	
Middle class	183 (16.7)	303 (21.6)	481 (15.9)	967 (17.5)	
Upper middle class	290 (26.6)	310 (22.1)	585 (19.4)	1185 (21.5)	
High/Rich class	303 (27.8)	130 (9.3)	570 (18.9)	1003 (18.2)	
Number of earning members					
No member earning	0 (0.0)	2 (0.1)	4 (0.1)	6 (0.1)	0.000
Only 1 member earning	549 (50.3)	808 (57.5)	1726 (57.1)	3083 (55.8)	
2-4 members earning	528 (48.4)	588 (41.9)	1252 (41.4)	2368 (42.9)	
>5 members earning	15 (1.4)	7 (0.5)	42 (1.4)	64 (1.2)	
Presence of BPL card					
No BPLCard[@]	867 (79.4)	1269 (90.3)	2428 (80.3)	4564 (82.7)	0.000
BPL Card	202 (18.5)	123 (8.8)	496 (16.4)	821 (14.9)	
Card for very poor family	23 (2.1)	13 (0.9)	100 (3.3)	136 (2.5)	
Other economic indicators					
Ownership of agricultural land	483 (44.2)	743 (52.9)	1689 (52.8)	2915 (52.8)	0.000
Ownership of land other than agricultural land	246 (22.5)	239 (17.1)	586 (19.4)	1071 (19.4)	0.003
Ownership of commercial land	9 (0.8)	4 (0.3)	4 (0.1)	17 (0.3)	0.002
Any member of the household has a bank account	910 (83.3)	894 (63.6)	2223 (73.5)	4027 (72.9)	0.000

**p-value is estimated on the basis of chi-square test
#Socio-economic status is calculated by giving weighted scores to 19 indicators and dividing in quintiles
* Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
@ BPL is Below Poverty Line
Figures in parenthesis denote percentages

The total constructed area of the household was also significantly different ($p<0.05$) across the three rural clusters. There were also significant differences in the ownership of agricultural and commercial land across three rural clusters. In the first cluster, the proportion of households with the ownership of agricultural land was less (44.2%) as compared to over 52 per cent in the second and third clusters. These observations have to been interpreted in the context of occupations; more men and women in the cluster one were doing regular jobs and less engaged in agriculture. In the first cluster, approximately one-fifth of the households (23.8%) had ownership of land other than agricultural land or commercial land as compared to 17.4 per cent households in the second cluster and 19.5 per cent households in the third cluster. Almost half of the households of the first cluster (49.8%) had more than two earning members as compared to the 42.4 per cent in the second and 42.8 per cent in the third cluster.

There were significant differences in the ownership of BPL card across three clusters (Table 4.8). In all the three clusters, almost 82.7 per cent of the population did not have any kind of BPL card. The ownership of bank account by any of the family members was also significantly different ($p<0.05$) across all the clusters. In the first cluster, 83.3 per cent of the households had ownership of the bank account as compared to the second cluster (63.6%) and third cluster (73.5%).This figure was higher than the census (2011) report that in the Palwal district, 59.9 per cent of the households were availing any kind of banking services.

There were significant differences in the type of ownership of the household in the three rural clusters (Table 4.9). In all the three rural clusters, more than 90 per cent of the families were staying in self-owned households. There were no significant differences in the household size in terms of the number of rooms in the household. Almost two third of the houses had 1-2 rooms (62.2%) and one third of the households had 3-5 rooms size (34.1%). There were significant differences in the type of household construction across three clusters (Table 4.9). The first cluster had a higher proportion of *"pucca"* households (79.2%) as compared to the second (64.3%) and third (63.2%) cluster.

Table 4.9: Distribution of the households in three rural clusters according to the household ownership, household size and household construction*

Indicators	Cluster 1 (n=1092)	Cluster 2 (n=1405)	Cluster 3 (n=3024)	Total (n=5521)	p-value**
Parcel/household ownership					
Self-owned parcel	1019 (93.3)	1358 (96.7)	3007 (99.4)	5384 (97.5)	0.000
Parcel on rent	2 (0.2)	3 (0.2)	9 (0.3)	14 (0.3)	
Relative's parcel	71 (6.5)	44 (3.1)	8 (0.3)	123 (2.2)	
Number of rooms in the house (household size)					
1-2 rooms	656 (60.1)	894 (63.6)	1907 (63.1)	3457 (62.2)	0.264
3-5 rooms	400 (36.6)	472 (33.6)	1013 (33.5)	1885 (34.1)	
More than 5 rooms	36 (3.3)	39 (2.8)	104 (3.4)	179 (3.2)	
Type of household construction					
Kuchha@	1 (0.1)	4 (0.3)	56 (1.9)	61 (1.1)	0.000
Pucca#	865 (79.2)	904 (64.3)	1913 (63.2)	3682 (66.7)	
Mixed@#	226 (20.7)	497 (35.4)	1055 (34.9)	1778 (32.2)	

Figures in parenthesis denote percentages. **p-value is estimated on the basis of chi-square test
*Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
@Kuchha construction of the household is defined as kuchha wall and kuchha roof construction of the house. #Pucca construction of the household is defined as pucca wall and pucca roof construction of the house. @#Mixed construction of the household is defined as mixed wall and mixed roof construction of the house

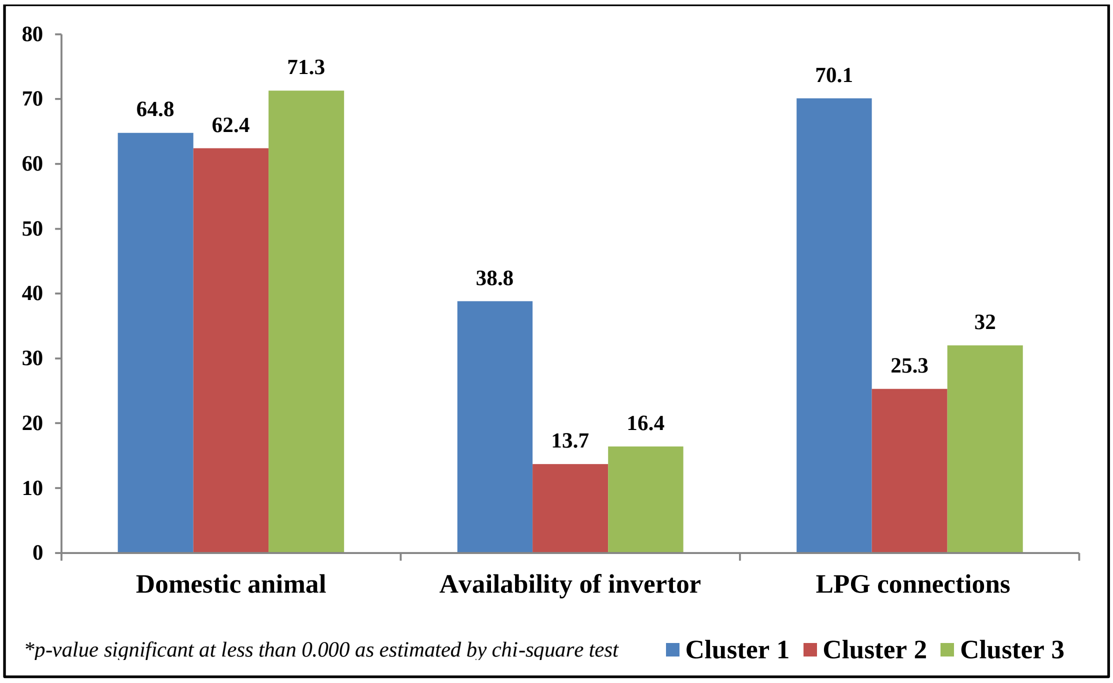


Figure 4.2: Cluster wise distribution of households according to different household facilities available in the household

There were also significant differences in the different facilities available in the household across the three different rural clusters (Figure 4.2). In the first cluster, 38.8 per cent of the households had the facility of an inverter and 70.1 per cent of the households had LPG connections as compared to lower availability in the second and third cluster. The overall availability of the LPG as a clean fuel for cooking was found to be similar to the figures (25.6%) reported by District Level Household Survey-4 (DLHS, 2012).

The possession of domestic animal is also an economic indicator in a rural economy. The purchase cost of the livestock animal per se, space required for keeping the domestic animal, cost incurred for cattle rearing are the factors, which contribute to domestic animal ownership becoming an economic indicator in a rural agrarian economy (IFAD, 2011; Radder et al, 2010). There were significant differences in the possession of domestic animal by the household across three clusters (Figure 4.2). The third cluster had the highest proportion of the household having the ownership of any domestic animal (71.3%) as compared to the second cluster (62.4%) and the first cluster (64.8%). This could also be due to the differences in the ownership of agricultural land and dependency on subsistence farming for livelihood across three rural clusters.

Social status of the household in the community and migration of any family members out of community were also another set of indicators representing the economic development of a society. The presence of this indicator was not expected in too many households in our community. Therefore, the percentage of the households representing development in terms of social status was very less in the society covered in the current research study. In continuation of other observations, the first cluster, had the highest proportion of households (2.7% households) having some kind of social membership in the community as compared to 1.5 per cent of the households in the second and third clusters. There were no differences in the migration patterns across the three clusters. While most indicators reflected greater prosperity in cluster one, the higher proportion of households in this cluster had BPL cards. It appears that use of BPL cards as a measure of the poverty and poor households in the area may not be valid reflection of the ground reality.

Thus, socio-economic profile of the three rural clusters was significantly different from each other on several parameters. The first cluster was distinctively better off than the other two clusters; cluster two and three were similar to each other on several accounts. These differences probably reflected the developmental differences in the three clusters located in three different locations of rural Palwal district.

4.1.3. Living Conditions of the Households

The three rural clusters situated in different locations of SOMAARTH DDESS of rural Palwal had different socio-demographic and socio-economic characteristics as evident from section 4.1.1 and 4.1.2. This section discusses the differences in the living conditions of the households of the three rural clusters. The indicators used for describing the living conditions of the household includes location of the place used for cooking food, presence of a bathroom, number of people sleeping in the same room, proof of smoke in the household, location of keeping domestic animals and place for washing clothes (Table 4.10). The quality of living conditions in turn has an impact on the nutritional status of the individuals living in the community.

There were significant differences among all the indicators of living conditions across three rural clusters (Table 4.10). First cluster was showing manifestations of better living conditions: higher proportion having a separate covered kitchen, infrequent occurrence of rooms with sooth and smoke effect of cooking, and less crowded living rooms. These observations were consistent with their improving socio-economic and educational status discussed in previous sections. In a developing society, the practice of cooking in an open courtyard declines with the adoption of cooking in a separate covered place/room (Census, 2011). More than 95 per cent of the households preferred to wash clothes within the plot where they lived since there was an easy access to water within the plot. However, in the third cluster, 6.3 per cent of the households were washing their clothes outside the plot as compared to 0.1 per cent and 0.5 per cent in the first and second cluster respectively (Table 4.10). This could be due to the presence of natural source of water in the form of pond/*johar* in the third cluster.

In the first cluster, a higher percentage of the households (47.9%) had a separate space for keeping the domestic animals outside the plot in which the family lived in comparison with the second cluster (35.4%) and third cluster (33.6%). Also, there were significant differences in the households having an animal shed for keeping the domestic animal across three clusters (Table 4.10). Overall, the practice of not having a bathroom with in the plot, and having domestic animals staying as part of the rest of the household were commonly observed although there was a trend towards improvement in these parameters in cluster one.

Table 4.10: Distribution of the households in three rural clusters according to the living conditions*

Household living conditions	Cluster 1 (n=1092)	Cluster 2 (n=1405)	Cluster 3 (n=3024)	Total (n=5521)	p-value**
Location of kitchen					
In the living room/or where people sleep	13 (1.2)	2 (0.1)	18 (0.6)	33 (0.6)	0.000
In a separate covered place/ room	156 (14.3)	53 (3.8)	231 (7.6)	440 (8.0)	
In open courtyard	923 (84.5)	1350 (96.1)	2775 (91.8)	5048 (91.4)	
Presence of bathroom#					
No bathroom/outside the plot	331 (30.3)	461 (32.8)	1099 (36.3)	1891 (34.3)	0.001
Within the plot	761 (69.7)	944 (67.2)	1925 (63.7)	3630 (65.8)	
Number of people sleeping in the room					
1-2 members	340 (31.1)	238 (16.9)	526 (17.4)	1101 (20.0)	0.000
3-5 members	724 (66.3)	1026 (73.0)	2099 (69.4)	3849 (69.7)	
>5 members	28 (2.6)	141 (10.0)	399 (13.2)	568 (10.3)	
Proof of smoke in the household					
In no room	994 (91.0)	987 (70.3)	1979 (65.4)	3960 (71.7)	0.000
In 1-2 room	97 (8.9)	415 (29.5)	1044 (34.5)	1556 (28.2)	
In >2 rooms	1 (0.1)	3 (0.2)	1 (0.0)	5 (0.1)	
Location of keeping domestic animal					
Inside the dwelling unit/plot	368 (52.0)	567 (64.7)	1431 (66.4)	2366 (63.3)	0.000
Outside the plot	340 (48.0)	310 (35.4)	725 (33.6)	1375 (36.8)	
Place for washing clothes					
Bathroom	14 (1.3)	21 (1.5)	154 (5.1)	189 (3.4)	0.000
Within plot	1077 (98.6)	1377 (98.0)	2681 (88.7)	5135 (93.0)	
Outside the plot	1 (0.1)	7 (0.5)	189 (6.3)	197 (3.6)	

*Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
Figures in parenthesis denote percentages**p-value is estimated on the basis of chi-square test
#Bathroom signifies only bathing area

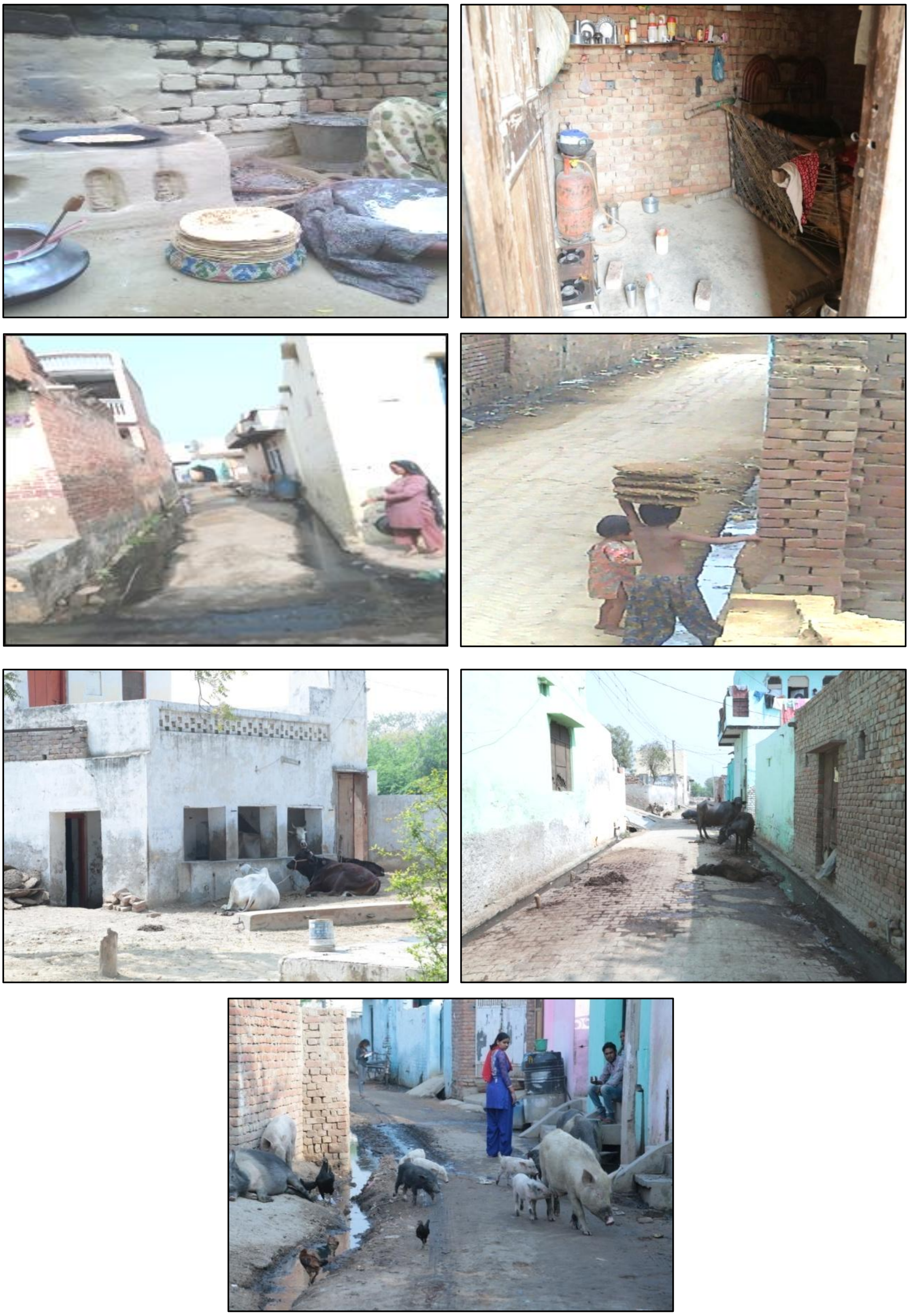


Figure 4.3: Different attributes of a household in the study site (Palwal district, Haryana)

According to District Level Household Survey-4 (DLHS, 2012), 95.5 per cent of the households in the Palwal district had electricity connections. Despite widespread availability of electricity connection, on the average, the electricity was available for one-third of the day in the three clusters. Solid biomass was used as the major source of cooking fuel in the rural economy (98.5%).

In the second cluster (situated near the NH-2 highway), around one-tenth of the households had some kind of leakage/seepage in the roof of the household (9.2%) as compared to only 1.8 per cent and 6.7 per cent in the first and third cluster respectively. Almost three-fourth of the households had acceptable ventilation in the household, though there were significant differences in the type of ventilation across the three rural clusters. Almost all the households reported breeding of mosquito/cockroaches/rodents representing poor hygiene characteristics of the household, with no significant differences across the three clusters. Figure 4.3 represents several of these characteristics of a household and its surrounding environment located in the study site.

Thus, the first cluster had significantly better living conditions as compared to the poor living conditions of the households in the second and third cluster. These differences in the living conditions of the households could be due higher socio-economic status and better education standards particularly among the women of the cluster one.

4.1.4. Environmental Hygiene Indicators

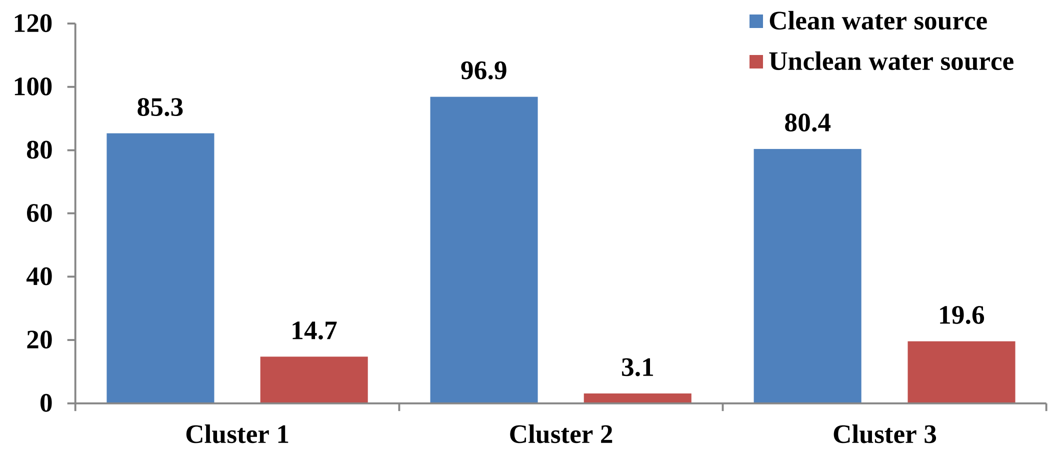
The fourth aspect of describing the differences in the three rural clusters was in terms of the ***environmental hygiene*** indicators. The socio-demographic and socio-economic profile of a household plays an essential role in determining the hygiene characteristics of the households. The environmental hygiene characteristics are described in terms of the source of drinking/cooking water, toilet facility and waste disposal mechanism used in the household. Different environmental hygiene indicators were unevenly distributed across the three rural clusters with no consistent patter (Table 4.11). Disposal of household waste and animal waste was in general unsatisfactory. The majorities of the households in the second cluster (96.9%) used clean sources of water vis-à-vis the first cluster (85.3%) and third cluster (80.4%) with significant differences ($p<0.05$) (Figure 4.4).

Table 4.11: Distribution of the households in the three rural clusters according to the different environmental hygiene indicators@

Indicators	Cluster 1 (n=1092)	Cluster 2 (n=1405)	Cluster 3 (n=3024)	Total (n=5521)	p-value*
Source of water used for washing utensils					
Clean water source@	1006 (92.1)	1369 (97.4)	2543 (84.1)	4918 (89.1)	0.000
Unclean water source@@	86 (7.9)	36 (2.6)	481 (15.9)	603 (10.9)	
Location of drinking water					
Within the dwelling unit/plot	389 (35.6)	1063 (75.7)	1938 (64.1)	3390 (61.4)	0.000
Outside the plot (within 100 feet)	114 (10.4)	175 (12.5)	363 (12.0)	652 (11.8)	
Outside the plot (>100 feet)	589 (53.9)	167 (11.9)	723 (23.9)	1479 (26.8)	
Toilet use by the adults					
Within the dwelling unit/plot	641 (58.7)	855 (60.9)	1457 (48.2)	2953 (53.5)	0.000
Outside the dwelling unit/plot	37 (3.4)	12 (0.9)	89 (2.9)	138 (2.5)	
Open field	414 (37.9)	538 (38.3)	1478 (48.9)	2430 (44.0)	
Toilet use by the children					
Within the dwelling unit/plot	735 (67.3)	910 (64.8)	1641 (54.3)	3286 (59.5)	0.000
Outside the dwelling unit/plot	28 (2.6)	12 (0.9)	85 (2.8)	125 (2.3)	
Open field	329 (30.1)	483 (34.4)	1298 (42.9)	2110 (38.2)	
Disposal of collected solid waste					
Open disposal^	1084 (99.3)	1398 (99.5)	2961 (97.9)	5443 (98.6)	0.000
Dustbin/sweeper	8 (0.7)	7 (0.5)	63 (2.1)	78 (1.4)	
Disposal of animal waste					
Open disposal	1084 (99.3)	1390 (98.9)	2995 (99.0)	5469 (99.1)	0.684
Distant from household	8 (0.7)	15 (1.1)	29 (1.0)	52 (0.9)	

*p-value is estimated on the basis of chi-square test
@ Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
^Open disposal includes disposal of waste within the plot in open/on road/in vacant land/near river
@ Clean water sources includes tap within the plot/public tap/hand pump/tube well/bore well/bottled water
@@Unclean water sources includes covered well/open well/tanker/from neighborhood
Figures in parenthesis denote percentages

In the first cluster more than half of the households (53.9%) had their water source located at a distance of more than 100 feet from their household of residence. High salinity of water was a characteristic feature of the water throughout the study site but the water was more saline in taste in the first cluster. Therefore, family members had to travel few kilometers every day to bring drinking water for the household. However, in the second cluster, three-fourth of the households (75.7%) had the source of drinking water located in their own household as compared to the other two clusters (cluster 1-35.6% and cluster 3-64.1%). The saline water of the first cluster could also play an important role in the reduced practice of farming and subsistence farming activities in that cluster. The clean sources of water include water from tap within the plot/public tap/hand pump/tube well/bore well/bottled water and the source of unclean water includes covered or open well/tanker/ water from the neighborhood. According to the District Level Household Survey-4 (DLHS, 2012), the facility of the improved source of drinking water have been improved from 87.2 per cent in 2007-08 to 98.1 per cent in 2012-13.

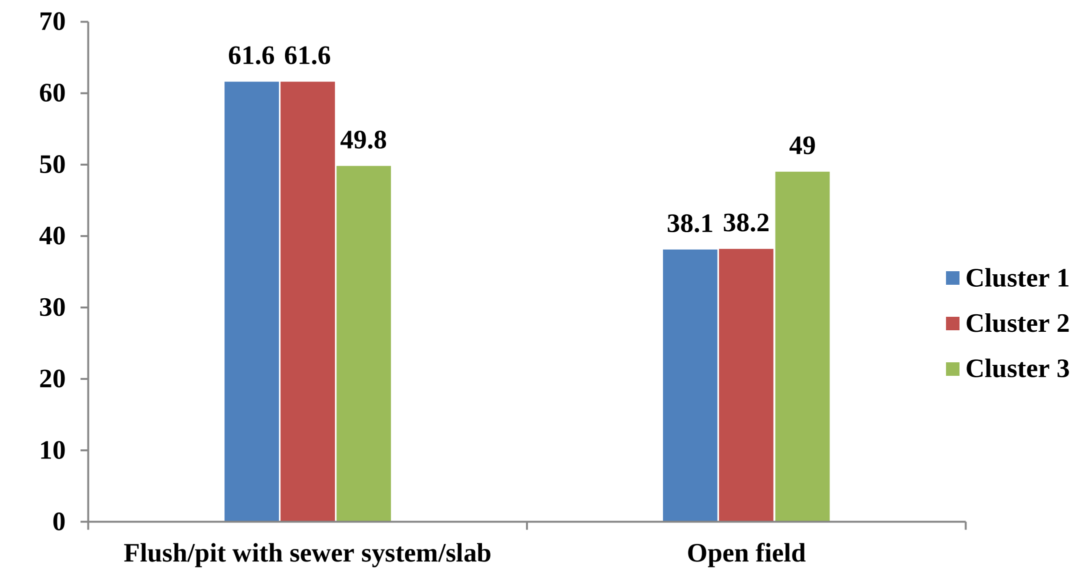


**p-value significant at less than 0.000 as estimated by chi-square test*
Clean water sources includes tap within the plot/public tap/hand pump/tube well/bore well/bottled water
^Unclean water sources includes covered well/open well/tanker/from neighborhood

Figure 4.4: Distribution of household according to the source of drinking and cooking water used in three rural clusters

The type of toilet constructed and its use by the household members are also vital indicators to determine the environmental hygiene of an area. Though more than 50 per cent of the household in all the three rural clusters had a constructed toilet in the form of a flush or a pit with a sewer system/slab (55.1%), still a large share of the households (44.1%) used open field for defecation purpose with significant differences ($p<0.05$) across the three clusters. This unhygienic practice could have detrimental influences on the nutritional status and health of the population in the area.

The open field was more frequently used by the adult members of the household (44.0%) as compared to children (38.2%) but with significant differences between clusters also. In cluster one and two where 38 per cent of the adults used open field for toilet purpose, in the third cluster the proportion of use of open field by adults was in 49 per cent (Figure 4.5).



**p-value significant at less than 0.000 as estimated by chi-square test*

Figure 4.5: Distribution of households according to the toilet facility used in three rural clusters

More than 60 per cent of the households reported to have an improved toilet facility in the Palwal district as reported by the District Level Household Survey-4 (DLHS-4, 2012). Thus, the three rural clusters had some differences with respect to environmental hygiene characteristics; overall environmental hygiene was not of acceptable level.

Therefore, the three clusters had differences from each other in terms of socio-demographic profile, socio-economic class and other economic indicator, household level living condition and facilities available, and the environmental hygiene characteristics of the community but there was no consistent pattern. Despite better economic condition of the households in the cluster one, the living conditions and environmental hygiene indicators were not uniformly better in cluster one compared to other two clusters. This may indicate that the area is in transition with social, economic and environmental indicators at different stages in the three clusters. Such characteristics could also influence the nutritional status and health of the population living in the community especially young children (6-12 years).

4.1.5. Health and Care Seeking Behavior

There were no major differences in the health seeking behavior of pregnant women and children in the three rural clusters (Table 4.12).

Table 4.12: Distribution of the households in three rural clusters according to the health seeking behavior[@]

Type of facility chosen	Cluster 1 (n=1092)	Cluster 2 (n=1405)	Cluster 3 (n=3024)	Total (n=5521)	p-value*
Pregnant women-General care					
Public/Govt. facility	99 (9.1)	110 (7.8)	66 (2.2)	275 (5.0)	0.000
Private facility	106 (9.7)	144 (10.3)	66 (2.2)	316 (5.7)	
Non-certified facility	887 (81.2)	1151 (81.9)	2892 (95.6)	4930 (89.3)	
Children-General care					
Public/Govt. facility	21 (1.9)	9 (0.6)	7 (0.2)	37 (0.7)	0.000
Private facility	40 (3.7)	20 (1.4)	17 (1.4)	77 (1.4)	
Non-certified facility	1031 (94.4)	1376 (97.9)	3000 (99.2)	5407 (97.9)	
Health insurance					
Number of households where any member has health insurance	85 (7.8)	36 (2.6)	196 (6.5)	317 (5.7)	0.000

@ Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
*p-value is estimated on the basis of chi-square test
Figures in parenthesis denote percentages

Very few households approached government health facilities for the care of their women and children. Nearly 95 per cent of the households chose non-certified health facility for the general care of children. Similarly most households sought care for their pregnant women from these informal care providers; 95 per cent of the households in the third cluster preferred a non-certified facility for general care and treatment as compared to 80 per cent in the other two clusters. This was due to the wide spread availability of these practitioners and hence ease of access along with nominal fee charged by these from their patients. This difference also could be due to the fact that these clusters are located near KMP and NH-2 highway, having an easy access of transportation facility to reach any private/public health facility as compared to the third cluster which is located deeper in the Mewat region.

Another aspect of health seeking behavior was having a health insurance, which in turn had a very frail penetration in the rural community (12%) across the country as reported by 70th round of NSSO survey (http://www.thehindu.com/sci-tech/health/policy-and-issues/health-insurance-in-india-too-little-too-scarce-reveal-national-sample-survey-data/article8462747.ece).The second cluster had the lowest penetration in this regard (Table 4.12).

In the second cluster, 26 per cent of the population reported consuming any type of tobacco which was much higher than that in the first (13.4%) and third (4.3%) cluster. There were some differences in the reported prevalence of chronic disease across the population of the three rural clusters (Table 4.13). The prevalence of chronic disease though very low was reported to be relatively highest in the first cluster.

Table 4.13: Distribution of the population in three rural clusters according to different lifestyle indicators and prevalence of any chronic disease[@@]

Indicators	**Cluster 1 (n=6,092)**	**Cluster 2 (n=9,144)**	**Cluster 3 (n=19,248)**	**Total (n=34,484)**
Lifestyle indicators				
Individuals consuming tobacco	814 (13.4)	2376 (26.0)	830 (4.3)	4020 (11.7)
Individuals consuming alcohol	121 (2.0)	28 (0.3)	117 (0.6)	266 (0.8)
Individuals suffering from disability[@]	130 (2.1)	199 (2.2)	106 (0.5)	435 (1.3)
Individuals having any Chronic disease				
Chronic diseases[#]	100 (1.6)	51 (0.6)	69 (0.4)	220 (0.6)
Chronic skin disease	1 (0.02)	5 (0.1)	6 (0.03)	12 (0.03)
Other chronic disease^	164 (2.7)	94 (1.0)	208 (1.1)	466 (1.4)

@@Cluster 1: Villages near KMP Highway; Cluster 2: Villages near NH-2 Highway; Cluster 3: Villages near Mewat region
@Disability is described as both mental and physical disability
#Chronic disease includes diabetes/hypertension/heart disease/brain disease/tumors or cancer/chronic cough or chronic lung disease
^Other chronic diseases includes joint pain or arthritis/chronic kidney disease/reproductive disorders/stomach or intestinal disorders/blood related disorders
Figures in parenthesis denote percentages

Section one describes the distinct characteristics of the three rural clusters which were located at different location in the SOMAARTH surveillance site. They had a different demographic profile, education and occupation profile of males and females, socio-economic status, household facilities, household living conditions, environmental hygiene indicators and health seeking behavior. Despite being significantly different from each other, all three rural clusters had poor living conditions and poor environmental hygiene.

4.2. Description of Sample (6-12 year old children; n=612)

A sample of 612 children (6-12 year old), both boys and girls were recruited from the three rural clusters located in different locations in the SOMAARTH demographic surveillance site. An equal proportion of girls and boys were recruited in all age bands (n=303 boys; n=309 girls) across the three clusters. The current section discusses the differences in the anthropometric and clinical profile (blood pressure) of the children (6-12 years), diet and physical profile of children (6-12 years), food availability and purchase behavior of household, built and food environment of the neighborhood, and eating and physical activity environment of schools in the three rural clusters of Palwal district, Haryana.

4.2.1. Socio-demographic and Socio-Economic Profile of the Study Subjects (n=612)

The demographic characteristics of the sample population i.e., 6-12 year age old children and their households are described in Table 4.14. Two-third of the recruited sample followed Hindu religion (67.8%) as compared to 31.9 per cent following Muslim religion: the first cluster was predominantly Hindu (98.0%) while second cluster was Muslim (61.3%).

More than half of the population belonged to the OBC category (55.2%) and the rest belonged to the SC/ST (17.5%) and general category (27.3%) with significant differences ($p<0.05$) across the three clusters. There were also differences in the household typology in terms of nuclear (61.1%), joint (32.4%) and extended (6.6%) families across the three rural clusters though not significant.

Table 4.14: Distribution of the sampled households in three rural clusters according to their socio-demographic profile (n=611)

Demographic characteristic	Cluster 1 (n=203)	Cluster 2 (n=204)	Cluster 3 (n=204)	Total (n=611)	p-value
Religion					
Hindu	199 (98.0)	79 (38.7)	136 (66.7)	414 (67.8)	0.000
Muslim	4 (2.0)	125 (61.3)	66 (32.4)	195 (31.9)	
Christian	0 (0.0)	0 (0.0)	2 (1.0)	2 (0.3)	
Caste					
Scheduled caste/tribe	65 (32.0)	10 (4.9)	32 (15.7)	107 (17.5)	0.000
Other backward classes	62 (31.0)	188 (92.2)	87 (42.7)	337 (55.2)	
General category	76 (37.4)	6 (2.9)	85 (41.7)	167 (27.3)	
Type of Household					
Nuclear	131 (64.5)	128 (62.8)	114 (55.9)	373 (61.1)	0.145
Joint	62 (30.5)	56 (27.5)	80 (39.2)	198 (32.4)	
Extended	10 (4.9)	20 (9.8)	10 (4.9)	40 (6.6)	

Figures in parenthesis denote percentages

In the current study, the third cluster represented nearly 45 per cent of the sampled households having joint and extended type of household vis-à-vis 35 per cent each in the first and second cluster respectively (Table 4.14). There was no significant difference in the mean family size (7.2 family members) across the sampled households. The mean family size in the study site was near to the family of 6 members reported in District Level Household Survey-4 (DLHS, 2012).

The sampled households in the three rural clusters represent significant differences ($p<0.05$) across different socio-economic class (Figure 4.6). The sampled households in the first cluster had higher proportion of lower middle class households (32.0%), the second cluster had a higher proportion of upper middle class and middle class households (47.1%), and the third cluster had a higher proportion of lower and lower middle class households (49.5%).Thus, there was a discordance between the average socio-economic class of the households in the three rural clusters (n=5,521) and the sampled households (n=611). As evident from the uniform distribution of households plotted on GIS maps, the children and their households recruited in the study were not recruited considering socio-economic status as the inclusion criteria.

Figure 4.6: Distribution of the sampled households according to their Socio-Economic status (n=611)

The paternal education and occupation profile of the sampled children was also significantly different ($p<0.05$) across the three clusters (Table 4.15).

Table 4.15: Distribution of the sampled households according to the paternal education and occupation profile of the recruited children (n=611)

Education and occupation categories	Cluster 1 (n=203)	Cluster 2 (n=204)	Cluster 3 (n=204)	Total (n=611)	p-value*
Education					
Illiterate	28 (13.9)	78 (38.4)	49 (24.3)	155 (25.5)	0.000
Primary schooling	7 (3.5)	10 (4.9)	7 (3.5)	24 (4.0)	
High schooling	64 (31.7)	59 (29.1)	54 (26.7)	177 (29.2)	
Secondary schooling	92 (45.5)	52 (25.6)	72 (35.6)	216 (35.6)	
Graduate	2 (1.0)	1 (0.5)	7 (3.5)	10 (1.7)	
Post graduate/ Professional degree	9 (4.5)	3 (1.5)	13 (6.4)	25 (4.1)	
Occupation					
Student/unemployed	4 (2.0)	4 (2.0)	10 (5.0)	18 (3.0)	0.000
Business/industry/shopkeeper	7 (3.5)	5 (2.5)	7 (3.5)	19 (3.1)	
Professional (self employed)	15 (7.4)	21 (10.3)	11 (5.5)	47 (7.7)	
Agriculture/Animal rearing	85 (42.1)	121 (59.6)	116 (57.4)	322 (53.1)	
Government/Private job/Pensioner	91 (45.1)	52 (25.6)	58 (28.7)	201 (33.1)	

*p-value estimated on the basis of chi-square test
Figures in parenthesis denote percentages

The second cluster had the highest rates of illiteracy among fathers of the recruited children (6-12 years) i.e. 38.4 per cent, as compared to 13.9 per cent in the first cluster and 24.3 per cent in the third cluster. The primary paternal occupation in more than 50 per cent of the study sample was agriculture/livestock farming (53.1%) and around one-third of the fathers were employed in the service sector of some kind (33.1%).

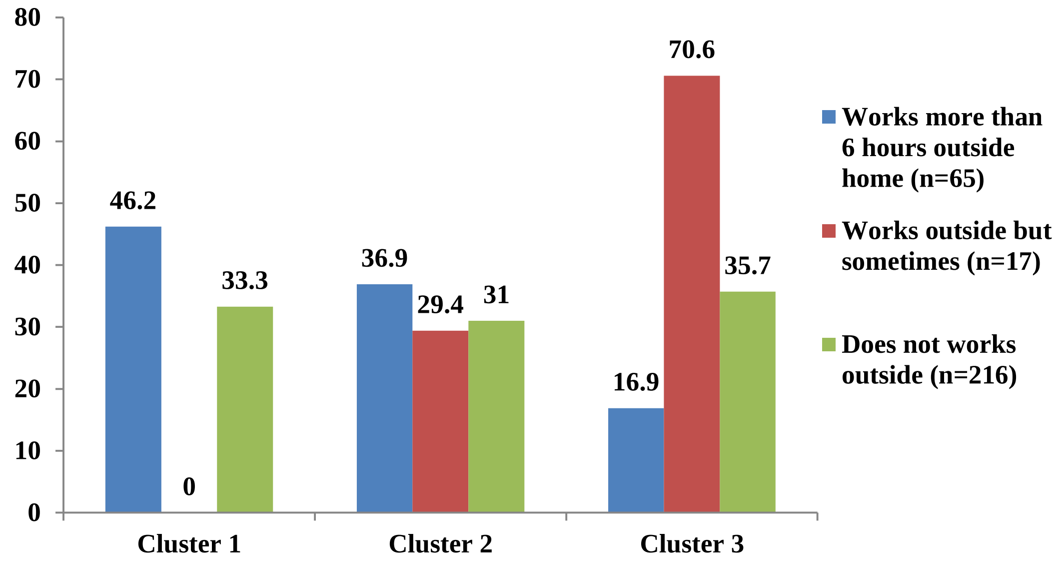
Maternal education is one of the essential determinants of the nutritional status of children (Dearth-Wesley et al, 2011; Chakraborty et al, 2010; Maddah et al, 2010). The maternal education profile was also significantly different ($p<0.05$) in the sample households across the three rural clusters (Table 4.16). In the study sample, three-fourth of the mothers had never been to school (73.2%). However, the proportions of mothers being illiterate varied across the three clusters. In the first cluster, more than one-third of the mothers had attained more than 5 year of schooling (36.2%) as compared to 16.3 per cent in the second cluster and 20.7 per cent in the third cluster respectively.

Table 4.16: Distribution of the households according to the maternal education and occupation profile of the recruited children (n=611)

Education categories	Cluster 1 (n=203)	Cluster 2 (n=204)	Cluster 3 (n=204)	Total (n=611)	p-value
Illiterate	123 (60.9)	165 (81.3)	158 (77.5)	446 73.2)	0.001
Primary schooling	6 (3.0)	5 (2.5)	4 (2.0)	15 (2.5)	
High schooling	50 (24.8)	29 (14.3)	28 (13.7)	107 (17.6)	
Secondary schooling	20 (9.9)	3 (1.5)	11 (5.4)	34 (5.6)	
Graduate	2 (1.0)	0 (0.0)	2 (1.0)	4 (0.7)	
Post graduate/Professional degree	1 (0.5)	1 (0.5)	1 (0.6)	3 (0.5)	

*p-value estimated on the basis of chi-square test
Figures in parenthesis denote percentages

The maternal occupation of the sampled households was significantly different ($p<0.05$) from each other when expressed in terms of the duration of work done outside home (Figure 4.7). The information regarding maternal occupation in terms of duration was derived from the qualitative data collected under the paradigm of the larger research program of which the current research study is associated. In the first cluster, 46.2 per cent of the mothers of recruited children worked for more than 6 hours outside home as compared to the second and third cluster (36.9% and 6.9%) respectively. In the third cluster, though, mothers were highly engaged in partial employment (70.6%) which allowed them to maintain a balance between contributing towards the family total income and child rearing.



**p-value is significant at less than 0.000 and estimated by chi-square test*

Figure 4.7: Distribution of the recruited children according to the maternal occupation (n=298)

Thus, in conclusion the sampled households of children in the age group of 6-12 years were significantly different in their socio-demographic and socio-economic characteristics. The education and occupation profile of the parents of the study subjects was different from the socio-demographic profile of the three clusters respectively. There was no systematic effort to select certain type of households. The GIS map indicated that the recruited households were scattered randomly in the nine villages. There were no significant differences in the refusals across clusters to participate in the study in terms of their key characteristics. The differences could have occurred due to selection of households with a pre-decided age band of children for the study.

4.2.2. Anthropometric and Blood Pressure Assessment among Children (6-12 years)

The anthropometric (height, weight, body circumferences, skinfold thickness) and clinical assessment (blood pressure) was done for children (6-12 years old) recruited in the current research study. The growth reference standards for children and adolescents (5-19 years) given by WHO (2007) were used to categorize children as underweight or stunted based on their weight-for-age (WAZ) AND height-for-age (HAZ) z-scores.

Table 4.17: Anthropometric measurements/indices among children (6-12 years) (Median, IQR and 95% CI)[*]

Anthropometric measurement and indices	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value**
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Height (cm)	127.4 (120.2, 136.4)[a]	125.5-129.4	129.4 (120.5, 138.3)[b]	127.0-132.6	132.0 (124.4 (141.5)[ab]	130.3-134.4	129.5 (121.4, 138.2)	128.7-131.1	0.0006
Weight (kg)	23.8 (19.9, 27.7)[a]	22.3-24.5	23.7 (19.9, 28.3)[b]	22.7-24.6	25.7 (21.6, 32.2)[ab]	24.5-26.8	24.2 (20.3, 29.1)	23.6-24.7	0.0003
BMI (kg/m^2)	14.4 (13.7, 15.4)[a]	14.2-14.6	14.2 (13.5, 15.3)[b]	14.0-14.5	14.8 (13.7, 16.2)[ab]	14.4-15.1	14.4 (13.6, 15.5)	14.3-14.6	0.0016

*p-value estimated on the Kruskal Wallis test and Dunn's test for post-hoc estimation. Same superscripts represents significant differences ($p<0.05$) as tested by Dunn's test

The median height, weight and BMI among children (6-12 year old) were 129.5 cm, 24.2 kg and 14.4 kg/m^2 respectively across all three clusters (Table 4.17). The height, weight and BMI of children residing in the third cluster was significantly different from the children in the first and second cluster as tested by post-hoc Dunn's test estimations. Puri et al (2008) reported a mean BMI of 16.7 kg/m^2 among 6-18 year old girls studying in low socio-economic status schools of Delhi.

The prevalence of underweight and severe underweight children in the study sample was 71.7 per cent and the prevalence was not different significantly across clusters (Table 4.18). Clearly, there was high prevalence of the chronic and acute malnourishment among the study population. This could be due to the higher illiteracy rates in the community, poor living conditions and poor environmental hygiene in the surroundings or households in general across the three clusters (Chirande et al, 2015; Kavosi et al, 2014; Ramirez-Zea et al, 2014; Bygbjerg 2012).

Table 4.18: Distribution of children (6-10 years) according to Weight-for-age (WAZ) categories #

WAZ categories	Cluster 1 (n=116)	Cluster 2 (n=100)	Cluster 3 (n=77)	Total (n=293)	p-value*
Severe underweight	11 (9.5)	13 (13.0)	7 (9.1)	31 (10.6)	0.08
Underweight	65 (56.0)	69 (69.0)	45 (58.4)	179 (61.1)	
Normal	40 (34.5)	18 (18.0)	25 (32.5)	83 (28.3)	

WAZ is estimated using growth reference standards given by WHO (2007) for children (5-10 years)
*p-value is estimated on the basis of chi-square test
Figures in parenthesis denote percentages

Along with the high prevalence of underweight, there was also a high prevalence of stunting and severe stunting among the sampled children (6-12 years of age); 25.1 per cent of children were stunted or severe stunted representing the presence of chronic malnourishment among children (Table 4.19 and Figure 4.8). There were no significant differences in the prevalence of stunting and severe stunting across the three clusters.

Table 4.19: Distribution of children (6-12 years) according to Height-for-age (HAZ) categories #

HAZ Categories	Cluster 1 (n=200)	Cluster 2 (n=192)	Cluster 3 (n=178)	Total (n=570)	p-value*
Severe stunted	13 (6.5)	10 (5.2)	17 (9.6)	40 (7.0)	0.3
Stunted	32 (16.0)	43 (22.4)	28 (15.7)	103 (18.1)	
Normal and very tall	155 (77.5)	139 (72.4)	133 (74.7)	425 (74.6)	

HAZ is estimated using growth reference standards given by WHO (2007) for children and adolescents (5-19 years)
*p-value is estimated on the basis of chi-square test
Figures in parenthesis denote percentages

Stunting indicates chronic malnutrition and may also reflect inter-generational influences of adverse nutritional environment (Prendergast and Humphrey, 2014). According to NFHS-3 data, 44.9 and 43.3 per cent of children (under 3 years of age) in India and Haryana were reported to be stunted (NFHS-3, 2005). We observed stunting in one-fourth of the study population in the background of very high prevalence of under-nutrition (almost 75%). These observations may indicate a more recent onset of malnutrition in the study children.

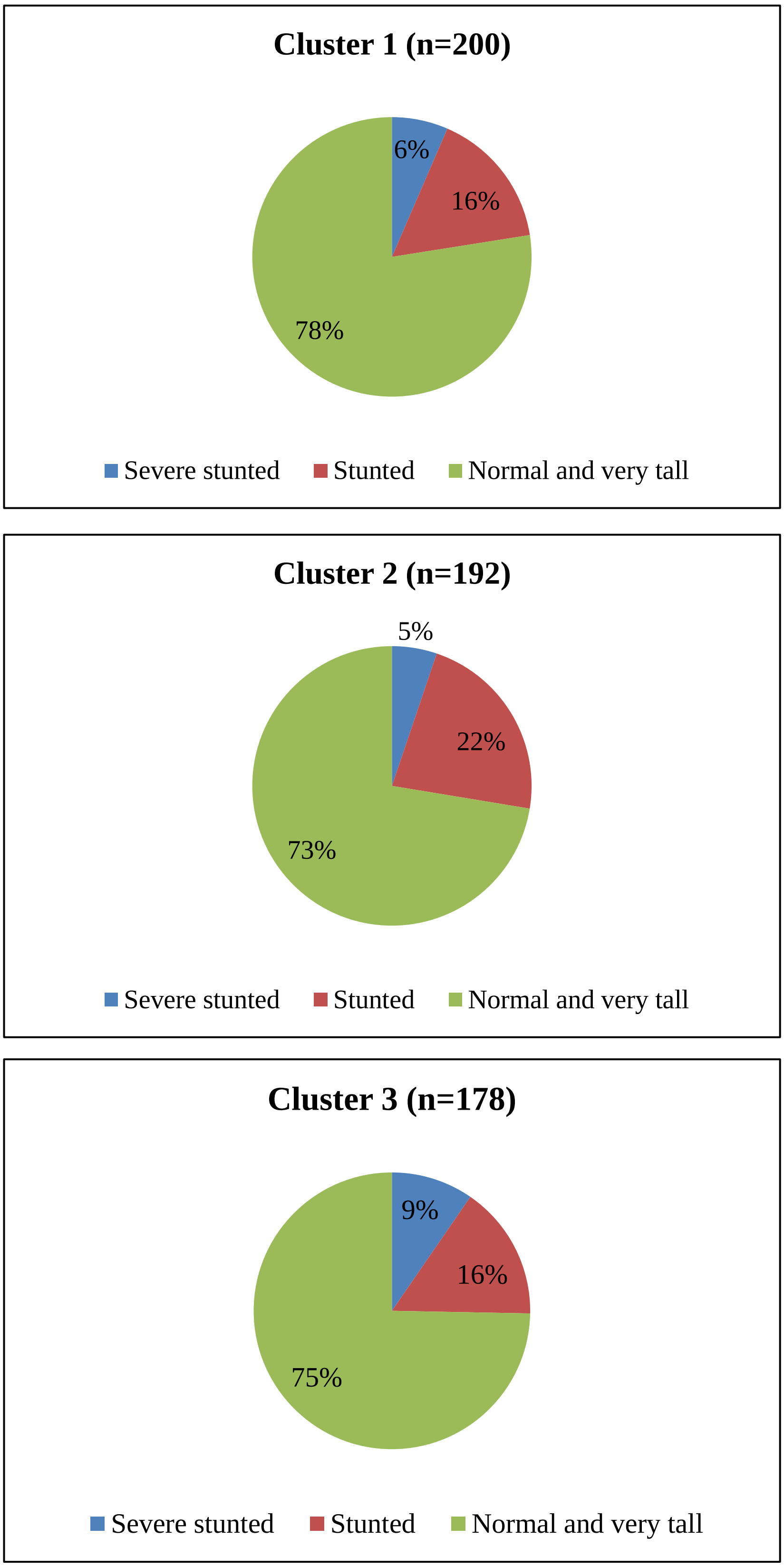


Figure 4.8: Prevalence of severe stunting and stunting among children (6-12 years) residing in three rural clusters and in different age and gender category

High prevalence of stunting has been reported from other parts of the country. The prevalence of stunting was 57.4 per cent among 3-9 years of children residing in Bhubaneswar, India (Panigrahi and Das, 2014), 19.9 per cent among 5-15 year olds residing in urban slums of Bareilly district (Uttar Pradesh) (Srivastava et al, 2012), 53.9 per cent among school-going children of tea garden workers in Assam (Medhi et al, 2006). Since large proportion of the children in the present research study would be entering their adolescence, the stunting prevalence in the study population appeared to be much less as compared to the high prevalence reported by other researchers. Stunting is a widespread problem in several low and middle income countries. The problem is particularly severe in South Asia (Aguayo and Menon, 2016; UNICEF, 2015). The prevalence of stunting has been reported to be more than 40 per cent among children of same age group residing in rural areas of Sub-Saharan Africa (Herrador et al, 2014). The proportion of children who were malnourished according to both their height and weight (i.e., simultaneous presence of underweight and stunting) status was nearly 10 per cent of the study sample. These children represent the most vulnerable group of children with impaired development and more prone to any kind of disease and illness.

The growth charts given by Khadilkar et al (2015) were used to classify children as thin or overweight or obese (BMI-for-age) since they used national data (n=33,148 children) and adult equivalent cut-offs for BMI classification for constructing the growth charts. There are significant differences in the prevalence of severe thinness/thinness and overweight/obesity across three clusters when classified according to BMI-for-age growth reference standards given by Khadilkar et al (2015). The prevalence of severe thinness and thinness was 28.7per cent in the second cluster as compared to nearly 19.0 per cent in the first cluster and the third cluster. The combined prevalence of overweight and obesity across three rural clusters was 3.0 per cent (Table 4.20). The national prevalence of childhood obesity was 4.6 per cent and the combined prevalence of overweight and obesity was 19.3 per cent as reported by Ranjani et al (2016). Regional differences in the prevalence of obesity across the country were reported (Prasad et al, 2016; Taneja et al, 2015). The prevalence of obesity among rural children (10-18 years of age) was 1.7 per cent in North India (Ambala district, Haryana) vis-à-vis 5.2 per cent in South India (Pondicherry). Puri et al (2008) reported combined prevalence of 5 per cent among 6-18 year old girls of low socio-economic status in New Delhi. On the other hand, similar prevalence of underweight were reported i.e., 29.2 per cent among boys and 24 per cent among girls (5-18 years) in rural and urban areas (AHS, 2014; NNMB, 2012). There were age and gender differences in the BMI-for-age among children (Figure 4.9). The prevalence of thinness/severe thinness was found to be higher among 10-14 year old boys and girls (25% and 29%) as compared to the children in younger age group.

Table 4.20: Distribution of children (6-12 years) according to BMI categories #

BMI Categories	Cluster 1 (n=200)	Cluster 2 (n=192)	Cluster 3 (n=178)	Total (n=570)	p-value*
Severe thinness and thinness	38 (19.0)	55 (28.7)	35 (19.7)	128 (22.5)	0.04
Normal	153 (76.5)	135 (70.3)	137 (77.0)	425 (74.6)	
Overweight and obese	9 (4.5)	2 (1.0)	6 (3.4)	17 (3.0)	

#BMI is categorized using growth charts given by Khadilkar et al (2015) for BMI-for-age for children and adolescents (5-18 years)
*p-value is estimated on the basis of fisher exact test
Figures in parenthesis denote percentages

The median MUAC, waist circumference and hip circumference was 16.9 cm, 53.7 cm and 63.0 cm among young children (6-12 year old) with significant differences across the three rural clusters (Table 4.21).

Central obesity is considered as one of the major cardio metabolic risk factor and is defined as waist circumference (in cms) greater than 90th percentile (IDF, 2014). The growth reference standards given by Khadilkar et al (2014) were used to classify children as being centrally obese or not. Across the three clusters, only one child was found to be centrally obese using this criteria.

The median body fat percentage among all the children was 12 per cent estimated using Slaughter and Lohman equation with significant differences across three rural clusters (Table 4.21). Due to the lack of unavailable growth reference standards for percentage body fat among children, the cut-offs given by given by Khadgawat et al (2013) for urban school going children of North India were used for classifying children into children with normal body fat, moderate body fat and elevated body fat. All the children fell within the normal range for body fat percentage except for one child who fell in high body fat percentage.

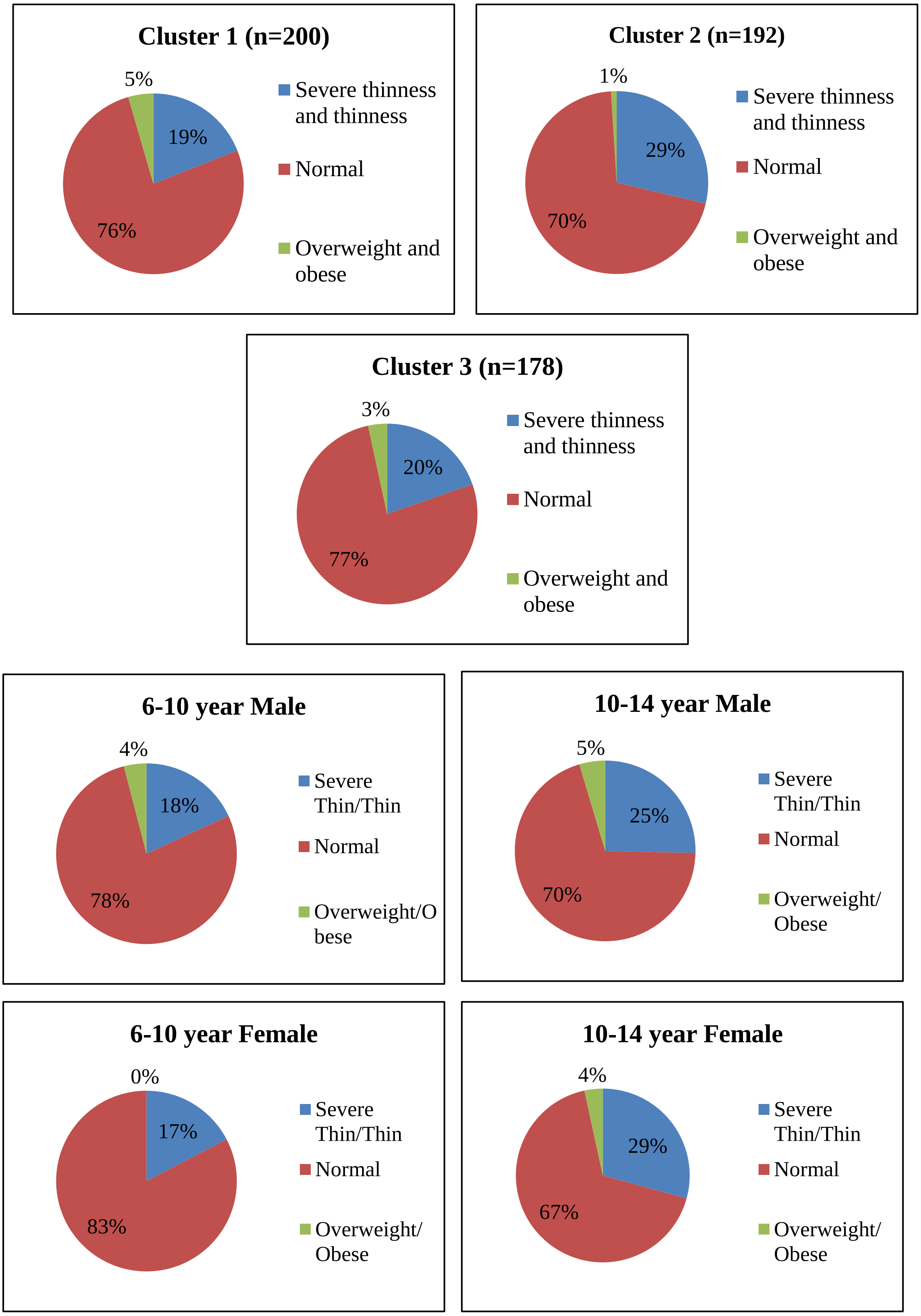


Figure 4.9: Prevalence of thinness and overweight/obesity among children (6-12 years) residing in three rural clusters and according to age and gender categories

Table 4.21: Anthropometric measurements/indices and Blood Pressure among children (6-12 years) (Median, IQR and 95% CI)

Anthropometric measurement and indices	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
MUAC (cm)	16.8 (15.6, 18.1)[a]	16.6-17.1	16.7 (15.5, 18.2)[b]	16.4-17.0	17.3 (15.8, 19.4)[ab]	17.0-17.7	16.9 (15.6, 18.4)	16.7-17.1	0.004
Waist circumference (cm)	53.1 (50.6, 57.2)[a]	52.3-53.8	53.8 (51.0, 57.2)[b]	53.0-54.4	55.3 (51.6, 58.6)[ab]	53.4-56.6	53.7 (51.0, 57.8)	53.3-54.4	0.004
Hip Circumference (cm)	62.3 (58.0, 68.2)[a]	61.1-64.2	62.3 (58.5, 67.0)[b]	61.2-63.4	64.8 (60.4, 70.7)[ab]	63.4-66.1	63.0 (58.6, 68.4)	62.3-63.9	0.0006
Percentage body fat (%)[$]	12.1 (10.1, 14.8)[ab]	11.5-12.3	11.1 (9.5, 13.5)[ad]	10.7-11.5	12.7 (10.6, 16.6)[bd]	12.1-13.6	12.0 (9.9, 14.8)	11.6-12.2	0.0001
Tricep (mm)	7.1 (5.8, 8.7)[ac]	6.6-7.2	6.4 (5.3, 7.7)[ad]	6.2-6.7	7.4 (6.1, 9.2)[cd]	6.9-7.8	6.8 (5.7, 8.5)	6.7-7.1	0.0001
Bicep (mm)	4.3 (3.6, 5.1)[ac]	4.1-4.4	4.1 (3.3, 5.1)[ab]	3.8-4.2	4.6 (3.5, 6.0)[bc]	4.3-5.1	4.3 (3.4, 5.4)	4.1-4.4	0.005
Sub-scapular (mm)	5.3 (4.5, 6.5)[a]	5.1-5.4	5.1 (4.4, 6.2)[b]	4.9-5.3	5.9 (4.7, 7.6)[ab]	5.4-6.1	5.3 (4.5, 6.7)	5.2-5.4	0.0007
Supra-iliac (mm)	4.3 (3.5, 5.4)[de]	4.1-4.5	5.1 (4.3, 6.9)[df]	4.9-5.4	6.7 (4.9, 9.4)[ef]	6.3-7.3	5.1 (4.1, 7.2)	4.9-5.3	0.0001
SBP (mm Hg)	108.3 (101, 115)[d]	106.3-110.3	108.7 (102.7, 115)[e]	107-110.7	113.7 (105.3, 123)[de]	111.3-115.3	109.7 (102.7, 116.7)	108.7-111	0.0001
DBP (mm Hg)	68.7 (64.8, 74.2)[ad]	67.5-70.3	70.3 (65.3, 76.8)[ae]	68.6-71.7	73.7 (69.3, 79.3)[de]	73.0-75.3	71.3 (66.3, 76.7)	70.3-72	0.0001

*p-value estimated on the Kruskal Wallis test and Dunn's test for post-hoc estimation. Same superscripts (a/b/c) represents the significant differences ($p<0.05$) as tested by Dunn's test. Same superscripts (d/e/f) represents the significant differences ($p<0.000$) as tested by Dunn's test.
[$]%Body fat is calculated using Slaughter and Lohman equation

The median fat fold thickness at tricep (6.8 mm), bicep (4.3 mm), sub-scapular (5.3 mm) and supra-illiac (5.1 mm) positions among children (6-12 year old) were significantly higher in the third cluster as compared to the other two clusters (Table 4.21). Overall there was trend towards higher anthropometric parameters in the third cluster though visible obesity was not more prevalent in this sub-group of children. The age-specific range of the mean fat fold at tricep (mm) for 6-12 year old children from the pooled data of ten states reported higher tricep values for females (7.9-9.3 mm) as compared to males (7.1-7.3 mm) (NNMB, 2012). In the present study also the median fat fold at tricep (mm) was significantly higher among females (7.6 mm) as compared to males (6.1 mm).

Despite age and gender differences in the anthropometric measurements, only cluster level stratification was done in the current research study due to the less sample size in each age, gender and cluster specific strata.

The median SBP (mmHg) and DBP (mmHg) among children in the 6-12 year age group was 109.7 mmHg (95% CI: 108.7-111.0) and 71.3 mmHg (95% CI: 70.3-72.0) respectively (Table 4.21). There were significant differences in the blood pressure values of the children across three rural clusters with the third cluster children having significantly higher levels. The age and gender adjusted values of SBP (mmHg) and DBP (mmHg) among children in the 6-12 year age group was 95.0 mmHg and 64.2 mmHg. This shows that with the increasing age adjusted for sex posed a greater risk of having high blood pressure among young children (6-12 year old). Similar results were reported by Raj et al (2010) where children and adolescents (5-16 years) had high values of both SBP and DBP especially among girls.

The high prevalence of hypertension among children increases the relative risk of other cardiovascular risk factors in adulthood (Falkner, 2015). The children in the current study were classified as pre-hypertensive or hypertensive based on the percentiles of blood pressure at 50^{th} percentile of height as given by Raj et al (2010). The prevalence of pre-hypertension and stage 1 and 2 hypertension based on BP was found to be high among children (6-12 years) with significant differences across three clusters (Table 4.22 and 4.23). Pre-hypertension and stage 1 and 2 hypertension was found among 17.6

per cent and 13.5 per cent of children in all the three rural clusters respectively. The combined prevalence of pre-hypertension and Stage 1 and 2 hypertension was found to be significantly higher among 6-12 year age children residing in the third cluster as compared to those residing in the first and second clusters. These findings coincide with the trend of marginally higher anthropometry parameters in the third cluster although most of these parameters were well within the normal range.

Table 4.22: Distribution of children (6-12 years) according to Systolic Blood Pressure (SBP) categories #

SBP Categories	Cluster 1 (n=200)	Cluster 2 (n=192)	Cluster 3 (n=177)	Total (n=569)	p-value*
Normal	143 (71.5)	142 (74.0)	107 (60.1)	392 (68.9)	0.000
Pre-hypertension	38 (19.0)	35 (18.2)	27 (15.3)	100 (17.6)	
Stage 1&2 hypertension	19 (9.5)	15 (7.8)	43 (24.3)	77 (13.5)	

#SBP is categorized using percentiles given by Manuraj et al , 2007
*p-value is estimated on the basis of chi-square test
Figures in parenthesis denote percentages

Table 4.23: Distribution of children (6-12 years) according to Diastolic Blood Pressure (DBP) categories residing in three rural clusters#

DBP Categories	Cluster 1 (n=200)	Cluster 2 (n=192)	Cluster 3 (n=177)	Total (n=569)	p-value*
Normal	167 (83.5)	151 (78.7)	124 (70.1)	442 (77.7)	0.01
Pre-hypertension	19 (9.5)	18 (9.4)	20 (11.3)	20 (10.0)	
Stage 1&2 hypertension	14 (7.0)	23 (12.0)	33 (18.6)	33 (18.6)	

#DBP is categorized using percentiles given by Manuraj et al, 2007
*p-value is estimated on the basis of chi-square test
Figures in parenthesis denote percentages

Some elevation of blood pressure among the rural children (6-12 year) may be due to the presence of anxiety during testing **(**Din-Dzietham et al, 2007**)**. The prevalence of pre-hypertension and stage 1 and 2 hypertension was found to be higher when the percentiles of blood pressure at 50thpercentile of height given by Bagga et al (2007) were used for estimating hypertension among children (6-12 year old). The combined prevalence of pre-hypertension and stage 1 and 2 hypertension according to the percentiles given by Bagga et al (2007) for SBP and DBP was 37.1 per cent and 22.3 per cent respectively.

The increase in the prevalence of hypertension was also reported by Dong et al (2013) among 7-17 year old children residing in China. The authors compared the two-time point trends of blood pressure in the pediatric population. The high prevalence of stage 1 and 2 hypertension among children could also be due to high intakes of sugar among children (as discussed in section 4.2.3) (Rosset et al, 2016; Siervo et al, 2013).

Therefore, in conclusion there were significant differences in the anthropometric and clinical profile of children (6-12 years old) in three rural clusters of Palwal district, Haryana. The prevalence of overweight and obesity is low among children but considering the rapid development in the rural community, there is a high probability of an increased prevalence of overweight and obesity among rural children in near future. Children recruited in the present research study being underweight and stunted have high levels of blood pressure. This places these children at a high risk of cardio-metabolic disorders including obesity at later stages of life (Falkner, 2015).

4.2.3. Dietary Profile of Children (6-12 years)

The dietary profile of children (6-12 year old) was assessed by 3-day 24 hour dietary recall and semi-quantitative food frequency questionnaire. The 3-day 24 hour dietary recall was done in a sub-sample (n=303). It was done by weighing all the food items cooked in the household and consumed by the subject in the past 24 hours using standardized utensils and a digital weighing machine. The data on intake of food from different food groups by the children (6-12 year old) is presented in Table 4.24.

4.2.3.1. Food Group Intake

The sample drawn for the current research study belongs to a rural agrarian economy where cereal and millets, milk and milk products are the major staple in the diet of the population. The presence of livestock in the households for the subsistence farming allows an ample availability and consequently intake of milk and milk products and fats (butter and *desi ghee*) in the household.

Cereals: The median cereal intake was nearly 248 g per day among 6-12 year old children with no significant differences across the three rural clusters. The size measure of a standard chapatti/roti/parantha in a rural community is larger as compared to the urban areas, resulting in a higher cereal intake among children (6-12 year old). However, the age and sex adjusted intake of cereals increased with increasing age among the children of the present research study. The intake of cereals and millet was higher than the recommended portions given by ICMR (2010) in the younger age children as compared to the 10-12 year old male and female children (Table 4.24). The primary source of cereals in the rural community was the home grown/self-produced cereal i.e., wheat. Palwal is among the highest wheat growing areas of the country. Traditionally millets like sorghum (*jowar*) were part of the diet of the rural community but now they seem to be disappearing from the plate of rural community. The market demand for millets is shrinking; the minimum support price of millets has also not matched up to make it remunerative for the farmers across the country including the study region. There has been changing eating pattern. Broken wheat (dalia) and millets were commonly eaten with milk and milk products (milk, curd, buttermilk, butter, desi ghee) but may not be so readily available now due to the reducing presence of domestic animals in the households of rural community. The cereals intake among children in present study was higher as compared to the 6-18 year old girls of low socio-economic status and upper socio-economic status in New Delhi was 203.4±44.6 g per day and 158.8±42.5 g per day respectively reported by Puri et al (2008). The total contribution of cereals to daily energy intake has been decreasing and 68^{th} round of NSSO survey conducted in 2011-12 reported that cereals contributed a total of 61.1 per cent to the total energy intake (NSSO, 2014). Auestad et al (2015) reported that breads, grains and cereals contributed a total of 14-18 per cent to the total energy intake among 2-18 year old children residing in Australia and United States.

Pulses and Legumes: The median intake of pulse was 19.4 g per day (95% CI: 12.2-36.5) among children (6-12 years) of rural community with significant differences ($p<0.05$) across three rural clusters with the higher intakes in the first cluster. In addition, the median intake of pulses and legumes was low when compared to the Recommended Dietary Intakes (RDI) across the three clusters. The age and sex adjusted intake of pulses and legumes was significantly higher for 10-12 year old male children as compared to the younger children (p value: 0.001; 95% CI: 8.1-30.5). The socio-economic conditions of the households, community level cooking practices (wherein, pulse based curries are cooked in an open vessel using solid biomass as fuel), reduced production and soaring high prices of pulses and legumes in the community, could have contributed to the reduction in their consumption (Reddy et al, 2013).The traditional practice of consuming "*sattoo (roasted Bengal gram flour consumed as a sugar-sweetened beverage or with buttermilk)*" and "*wheat and chana flour chapatti (gochni ki roti)"* has also disappeared in the rural community (Table 4.24). The overall pulse consumption has also reduced at the national level; although the percentage contribution of pulses to the total energy intake has increased from 4.5 per cent (2009-10) to 5.2 per cent (2011-12) as reported by NSSO in the 68th round of survey (2014). The meta-analysis of the feeding trials has shown that the consumption of pulses and legumes in the daily diet lowers the risk of chronic disease and improved dietary quality by enhancing the satiety level of the food consumed (Li et al, 2014). However, in the present study, the pulse consumption was found to be very low.

Milk and milk products: Milk and milk products forms the major component of the diet of the children in the rural community. The major food item in this food group includes milk (buffalo/cow/goat), curd, butter milk. The median intake of milk and milk products among the rural children in the present study was 338.3 g per day (95% CI: 198.5-519.5). However, there were no significant differences in the consumption of milk among children (6-12 year) old when adjusted for age/sex and location of residence across the three rural clusters. This states that irrespective of the socio-economic condition of the household, or the ownership of livestock, milk was an essential component of the diet among rural households and their children. Milk and milk products were found to contribute 8 per cent to the total energy intake and one-fifth of the daily saturated fat among 2-18 year old children in Australia and Unites States as reported by a national level secondary analysis conducted by Auestad et al (2015). High intakes of dairy products were also reported by Fiorito et al (2006) among 7 year old girls. The dairy products were found to be contributing a total 19.3 per cent to the total energy intake (1824.6±350.9 kcal) in the girl's daily intake.

"main to apne bache ko bahut sara dhoodh pilati hoon. ussi se takat aati hai. gaon mein reh kar bhi dhoodh, dahi, ghee nahin khaya to kya khaya. Katora bhar bhar ke dhoodh peeta hai"

(Mother of a child, cluster 3)

Table 4.24: Food group intake (g) among children (6-12 years) (n=303) (Median, IQR and 95% CI) #

Food groups	Cluster 1 (n=102)		Cluster 2 (n=100)		Cluster 3 (n=101)		Total (n=303)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Cereal and Millets (g)	243.6 (194.9, 312.7)	215.1-257.0	248.0 (194.0, 326.7)	230.2-273.3	258.5 (207.7, 323.9)	233.4-274.4	247.6 (199.6, 315.6)	240.-260.0	0.30
Pulses and legumes (g)	22.3 (13.8, 42.2) [a]	19.1-26.5	21.7 (12.5, 39.2) [b]	17.0-25.6	16.8 (10.6, 26.9) [ab]	14.1-19.3	19.5 (12.2, 36.1)	18.2-22.9	0.03
Milk & milk products (g)	337 (200.8, 549.1)	299.3-442.6	333.4 (184.6, 503.7)	254.3-390.7	375.4 (207.2, 554.0)	291.6-419.8	338.3 (190.3, 521.9)	311.1-388.1	0.46
Meat, fish & poultry (g)	0 (0, 0) [ab]	0-0	0 (0, 10.6) [ab]	0-0	0 (0, 0) [a]	0-0	0 (0, 0)	0-0	0.001
Fruits (g)	62.2 (28.1, 101.9) [ab]	40.6-79.2	37.6 (14.7, 107.5) [a]	26.1-72.2	39.3 (12.7, 77.3) [b]	29.9-54.8	44.1 (19.8, 95.1)	38.2-59.6	0.04
Vegetables (g)	171.3 (94.3, 224.8) [a]	153.5-180.6	112.5 (77.7, 167.7) [ab]	98.8-131.3	151.2 (87.5, 216.7) [b]	131.3-175.6	144.7 (86.9, 207.3)	129.9-157.5	0.003
Sugars (g)	47.5 (35.4, 78.8)	41.7-59.5	63.2 (42.7, 92.7)	54.8-70.5	57.6 (37.1, 93.5)	49.4-67.7	56.7 (37.9, 85.2)	50.5-62.7	0.09
Fats (g)	31.5 (21.9, 43.7) [a]	27.6-35.1	25.6 (18.1, 42.6)	23.0-31.9	22.5 (13.8, 38.2) [a]	19.8-27.8	27.3 (17.9, 41.8)	24.9-30.6	0.02

#Food group intake is assessed using 3-Day 24 hour Diet recall
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts represents the significant differences ($p<0.05$) as tested by Dunn's test

The consumption of dairy in higher amounts in the form of full-fat milk, flavored milk, yogurt or other dairy products have been associated with an inverse relationship and lower odds of getting overweight/obese, abdominal obesity, blood pressures and insulin resistance and high levels of blood glucose (Abreu et al, 2014; Bigornia et al, 2014; Yuan et al, 2013; Lin et al, 2012).

The dilution factor (proportion of water added to the whole milk) was taken into account for estimating the appropriate quantity of milk intake. In all the clusters, water was added in high quantities for increasing the quantity of milk to suffice for the household. The rate of dilution was observed to be determined by socio-economic differences and demographic differences in the rural community. Being an agrarian economy, the families did not prefer to procure milk from the market in times of lean period of the livestock.

Fruits and vegetables: The median intake of fruits and vegetable was 43.2 g per day and 144.7 g per day among the children respectively (Table 4.24). There were significant differences ($p<0.05$) in the intake of both fruits and vegetables among children residing in three rural clusters; highest intake was in found in the first cluster. The vegetable intake among children residing in the second cluster (112.5g/d) was lower as compared to those living in the first (171.3g/d) and third (151.2g/d) cluster respectively. The roots and tubers had a major share in the total intake of vegetables among rural children (71g/d). The intake of fruits and vegetables was very low as compared to the recommended intakes (Figure 4.10). This could be attributed to the soaring high prices of fruits and vegetables in the community, scant availability of fruits in the neighborhood, socio-economic condition of the household, demographic characteristics of the household like maternal education and occupation (since mother was the one who was responsible cooking food and feeding to the child in the household). In the first cluster, the intake of fruit intake could be high due to the local production of some fruits in the village (guava, zizyphus and jamun). The age and sex adjusted fruit and vegetable intake had no significant differences across different age groups except the higher intake of vegetables among 10-12 year old male children as compared to the 6-year-old children.

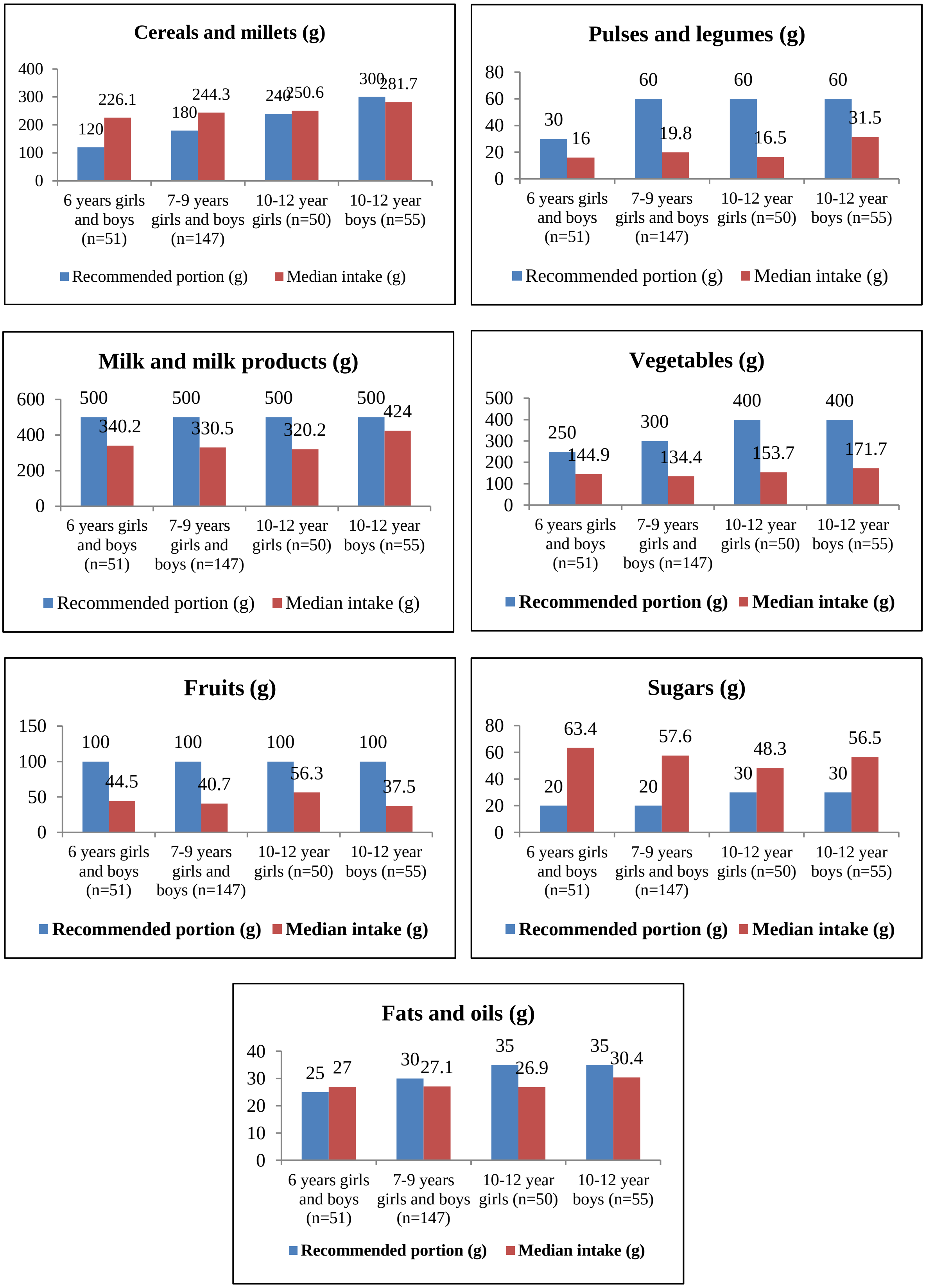


Figure 4.10: Median and recommended intake of different food groups among children (6-12 years)

Meat, fish and poultry: There was practically little consumption of meat, fish and poultry in the study population. Cluster two was consuming these somewhat more than the children from other clusters. These differences could be attributed to major demographic differences in the religion of the households and community. It was also observed in the rural community that demographic features of the community (especially religion) were essential influencers for governing the availability of food items in the respective food group at the community level (Table 4.24).

Fats and oils: The median intake of visible fats and oils among children (6-12 year old) was 27.3 g per day (95% CI: 17.6-41.8). There were significant differences in the fat intake across three rural clusters with the highest consumption among the children residing in the first cluster. However, when intake was adjusted for age and sex, differences among clusters disappeared. The major source of visible fat intake among children was the white butter or *desi ghee*. The intake of fats and oils among children was lower than the recommended intake (Figure 4.10).

Sugars and their products: The sugar intake (56.7g/d; 95% CI: 37.9-85.2) was found to very high when compared to the RDI among rural children (6-12 year old) residing in three rural clusters (Figure 4.10). When adjusted for age and sex there was significant higher sugar intake among the younger children (6-year-old girls and boys).The major sources of sugar include sugar, sugarcane, grounded sugar (*boora*), *khand*, and jaggery. Wheat based chapatti being the most essential staple was consumed with milk-based products (milk/curd/buttermilk), sugar based products (jaggery/sugar/boora) and fats (ghee/butter). The high intake of sugars among children residing in the rural community could be attributed to the following factors: local production of sugarcane, jaggery/boora with ghee act as substitutes for vegetables in the diet. The insignificant difference in the sugar intake among children residing in three rural clusters indicated that in the rural area differences in the household level attributes, demographic features and socio-economic conditions did not influence the process of sugar intake; it may be more local food practice in the context of easy availability (Table 4.24).

Unhealthy foods: The intake, frequency and caloric contribution of unhealthy foods was derived from the semi-quantitative questionnaire. The median intake of unhealthy foods was 169.4 g per day with a daily *frequency* of 3.5 times; was significantly different across the three clusters (Table 4.25 and Table 4.26). The total calories per day derived from the unhealthy foods was also significantly higher among children residing in the second cluster (781 kcal) as compared to the children in the first (604.9 kcal) and third cluster (567.1 kcal) respectively. The total consumption of unhealthy foods contributed to a median 21.3 per cent to the total energy intake (kcal) as derived from the semi-quantitative food frequency questionnaire. The per cent contribution of unhealthy foods among the children in the second cluster was significantly higher (25.7%) as compared to the children in the first (18.1%) and the third cluster (18.3%). Snacks and sweets were found to contribute 17 per cent to the total energy intake among 2-18 year old children in Australia and Unites States as reported by a national level secondary analysis conducted by Auestad et al (2015).

Table 4.25: Unhealthy food intake (g) and contribution to total calorie among children (6-12 years) (n=568) (Median, IQR and 95% CI)#

Food groups	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Unhealthy foods (kcal)$	605 (372, 932) a	547-655	781 (478, 1136) ad	706-863	567 (318, 879) d	489-666	655 (386, 989)	603-698	0.0001
Unhealthy foods-calorie % #@	18.1 (12.5, 26.3) d	16.3-20.8	25.7 (19.4, 32.6) de	24.4-27.8	18.3 (12.7, 27.7) e	15.9-20.9	21.3 (14.1, 28.7)	20.0-22.5	0.0001

#Food group intake is assessed using semi-quantitative Food Frequency Questionnaire
$Unhealthy food is defined as food rich in salt, sugar and fats. The following food categories are included: Sweets and confectionaries, salty fried and packaged snacks, bakery products and sugar sweetened beverages
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences (p<0.05) and (d/e) represents the significant differences (p<0.0000) as tested by Dunn's test

The major unhealthy foods include salty and fried snacks (loose and packaged), sweets and confectionaries, bakery products. There were no recommendations for the quantity of unhealthy foods to be consumed by children. The age and sex adjusted intake of total calories from unhealthy foods does not have significant differences among children in all age groups; although there were trends of increasing calorie intake from unhealthy foods with age. There are also increasing intakes of ultra-processed foods among children in Brazil (47%) and Canada (61%) (Sparrenberger et al, 2015; Moubarac et al, 2013). The ultra-processed foods in the studies were defined on the basis of classification proposed by Monteiro et al (2010). However, following findings contradict with each other i.e., the high intakes of unhealthy foods and the high prevalence of severe thinness/thinness. The proportion of calories derived in the study population from unhealthy food was higher compared to their western counterparts. This is worrisome as the local living conditions, life style and factors influencing food absorption change, the children may have the potential to become obese (Funtikova et al, 2015).

"Ajkal ke khane se to ga banti hai.
Isliye ab dalia bhi koi nahin khata gaon mein.
Sab piece paape khate hain chai ke saath subah sham"

(Grandmother of a child, Cluster 2)

Figure 4.11: Variety of unhealthy foods available in neighborhood market

Table 4.26: Unhealthy food intake (g) and frequency of consumption among children (6-12 years) (n=568) (Median, IQR and 95% CI)#

Food groups	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Intake of Unhealthy foods (g)									
Sugar dishes (g)	14.3 (4.2, 38.3) ad	9.7-22.5	56.4 (22.2, 209.3) de	42.7-71.4	25.2 (11.0, 47.4) ae	22.0-30.6	27.6 (7.8, 69.2)	25.0-32.2	0.0001
Sweets and confectionaries (g)	36.2 (21.4, 59.7) d	30.6-38.9	51.5 (26.8, 85.4) ad	42.1-60.2	39.2 (22.4, 64.4) a	34.9-45.1	39.6 (22.8, 69.8)	37.1-43.5	0.0004
Salty and fried snacks (g)	67.6 (38.6, 112.0) ad	60.4-83.3	53.4 (28.7, 86.1) ab	48.3-59.8	45.6 (23.1, 78.3) bd	36.3-51.3	55.6 (29.4, 92.6)	50.7-60.5	0.0001
Sugar sweetened beverages (g)	1.5 (1.0, 15.8) d	1.2-1.5	39.5 (11.8, 197.2) ed	34.3-68.6	1.6 (0.8, 2.6) e	1.6-1.6	2.0 (1.0, 34.3)	1.6-2.7	0.0001
Bakery food products (g)	30.3 (12.1, 52.9) ad	23.0-35.1	47.7 (20, 78.7) ed	42.1-55.0	18.7 (7.9, 51.8) ae	14.5-26.9	32.9 (12.1, 62.7)	27.2-35.7	0.0001
Frequency of consumption (Unhealthy foods)									
Unhealthy foods $	3.6 (2.2, 5.0) a	3.1-4.1	3.9 (2.7, 5.2) d	3.6-4.2	2.9 (1.7, 4.2) ad	2.5-3.3	3.5 (2.1, 4.7)	3.2-3.7	0.0001
Sweets and confectionaries	0.8 (0.4, 1.2)	0.7-1.0	0.8 (0.4, 1.4)	0.7-1.0	0.8 (0.4, 1.3)	0.7-0.9	0.8 (0.4, 1.3)	0.8-0.9	0.5
Salty and fried snacks	1.3 (0.7, 2.0)	1.1-1.4	1.2 (0.7, 1.7)	1.1-1.3	1.2 (0.6, 1.7)	1.0-1.3	1.2 (0.6, 1.8)	1.1-1.3	0.25
Sugar sweetened beverages	0.0 (0.0, 0.1 ad	0.0-0.0	0.1 (0.0, 0.6) de	0.1-0.3	0.0 (0.0, 0.0) ae	0.0-0.0	0.0 (0.0, 0.1)	0.0-0.01	0.0001
Bakery food products	0.7 (0.3, 1.3) ab	0.6-1.0	1 (0.6, 1.3) ad	0.9-1.1	0.6 (0.2, 1.0) bd	0.4-0.6	0.7 (0.3, 1.1)	0.6-0.9	0.0001

#Food group intake is assessed using semi-quantitative Food Frequency Questionnaire
$Unhealthy food is defined as food rich in salt, sugar and fats. The following food categories are included: Sweets and confectionaries, salty fried and packaged snacks, bakery products and sugar sweetened beverages
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0000$) as tested by Dunn's test

The availability of unhealthy foods in the neighborhood market influences the intake of unhealthy foods by the subjects. The unhealthy foods consumed by children include locally produced refined flour based puffs "pola" (available in various shapes, sizes, colors), refined flour and sugar based imitates of sweets "barfi/laddoo/patisha", candies, chips and allied salty snacks, fried snacks, sweets, bakery products like breads, rusk, fan (Figure 4.11). The flourishing availability of unhealthy food items in the neighborhood community and local production at the village level could be the contributing factors for an increased intake among children (6-12 year old). The branded and unbranded snacks available in the rural Palwal district, Haryana have been reported to have high content of saturated fats and trans-fats (Gupta et al, 2016). It was observed in the community that these unhealthy food items were cheap and were easily affordable by the children. However, children barters the purchase of unhealthy foods like pola, sweet imitates or chips with the scrapped household commodities, grains and hairs. Thus, the unhealthy foods were available, accessible and affordable to the children residing in three rural clusters of the Palwal district, Haryana.

4.2.3.2. Nutrient Intake

Three day 24-hour dietary recall was used to assess the energy (kcal) and macronutrient intake among children (6-12 year old) residing in three clusters.

Energy (kcal): The median energy intake among children (6-12 year old) was 2138 kcal per day (95% CI: 2051-2244). There were no significant differences in the total energy intake across the children residing in the three rural clusters (Table 4.27). The median energy intake was also higher among children vis-à-vis the RDA across all age groups (Figure 4.12). The finding was contrary to the finding of a high prevalence of thin and severe thin children in the current study sample. Literature has shown that any kind of morbidity (infections, diarrhea or fever) affect the utilization of nutrients in among children and hence leads to chronic or acute malnutrition (Herrador et al, 2014; Amare et al, 2013; Mahmud et al, 2013).The present research study lacks empirical data on the actual morbidity profile of children (6-12 year old). Therefore, the high prevalence of thinness/severe thinness cannot be explained in a straight forward manner among study children. There are some indicators in the environmental data and profile of food items being consumed by the children. The data related to environmental hygiene and sanitation show less than optimal conditions. The children in the area were consuming 20-25 per cent of their calories which can be termed as unhealthy (Table 4.25 and Section 4.2.3.1). These factors may be influencing the nutrient availability.

Table 4.27: Energy (kcal) and macronutrient (g) intake and per cent contribution of macronutrient among children (6-12 years) (n=293) (Median, IQR and 95% CI)#

Energy and Nutrient	Cluster 1 (n=102)		Cluster 2 (n=96)		Cluster 3 (n=95)		Total (n=303)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Intake of Energy (kcal) and Macronutrient (g)									
Energy intake (kcal)	2056 (1774, 2476)	1925-2200	2116 (1719, 2574)	1927-2357	2232 (1853, 2780)	2073-2469	2135 (1783, 2558)	2051-2244	0.14
Carbohydrate (g)	293.3 (245.0, 338.8)[ab]	261.5-306.0	323.1 (249.2, 377.0)[a]	289.2-345.5	323.2 (271.3, 388.2)[b]	308.6-357.3	309.5 (252.6, 377.7)	299.4-321.8	0.01
Protein (g)	49.4 (40.6, 58.0)[a]	44.9-52.2	51.8 (43.0, 62.4)[b]	48.6-57.1	58.7 (45.1, 70.6)[ab]	53.5-63.4	52.6 (42.7, 64.6)	50.1-55.6	0.0006
Fat (g)	68.9 (53.8, 87.5)	60.9-76.0	63.7 (41.8, 87.4)	54.1-72.6	68.4 (50.4, 96.5)	61.3-75.1	66.7 (49.3, 89.0)	62.5-72.0	0.34
Per cent contribution of macronutrient and unhealthy foods to the total dietary intake									
Carbohydrates en%	56.4 (51.2, 62.8)[ab]	55.4-58.7	60.6 (53.5, 67.1)[a]	58.0-63.5	58.5 (53.6, 64.7)[b]	57.2-61.0	58.5 (53.0, 64.7)	57.4-59.9	0.02
Protein en%	9.5 (8.9, 10.1)[ad]	9.2-9.6	9.8 (9.1, 10.8)[ab]	9.6-10.2	10.4 (9.5, 11.1)[db]	10.0-10.8	9.7 (9.1, 10.8)	9.6-10.0	0.0001
Fat en%	30.6 (25.3, 35.1)[ab]	28.7-32.3	27.0 (21.0, 32.7)[a]	24.8-28.8	28.5 (22.5, 32.1)[b]	25.6-30.3	28.8 (22.9, 33.4)	27.5-29.6	0.003

#Total energy (kcal) & Macronutrient intake (g) and their % contribution to total energy has been computed from 3-day 24 hour diet recall (n=303) and % contribution of unhealthy foods has been derived from semi-quantitative Food Frequency Questionnaire (n=568)

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences (p<0.05) and (d/e) represents the significant differences (p<0.0001) as tested by Dunn's test

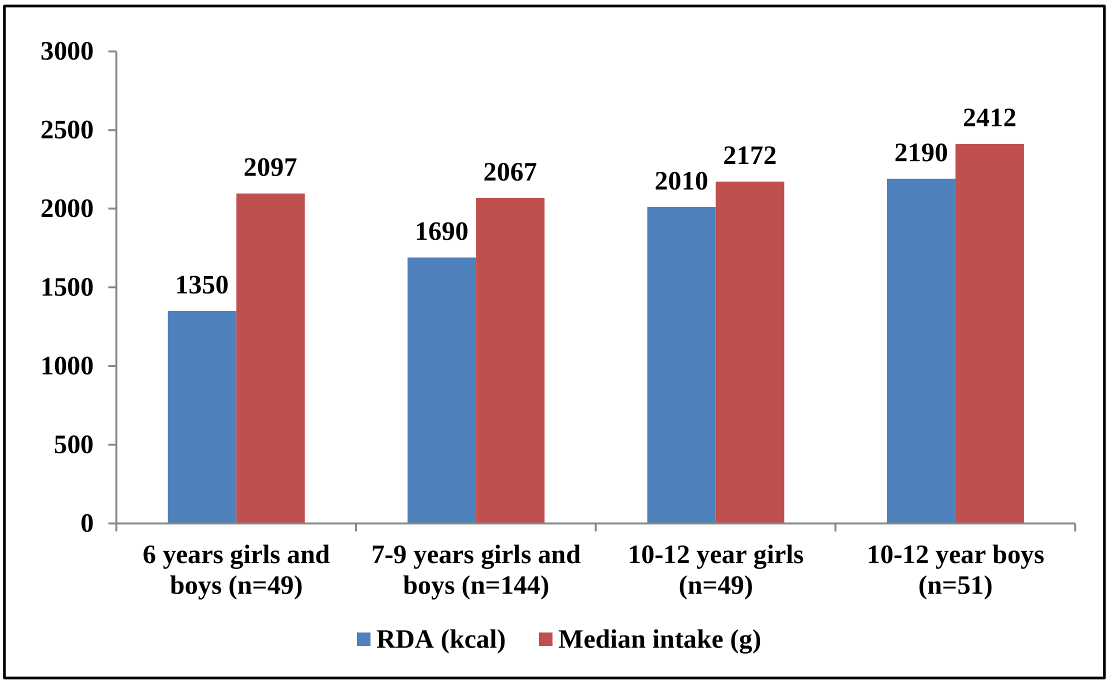


Figure 4.12: Median intake of energy and RDA among 6-12 year old children residing in three rural clusters (n=303)

Based on the regression analysis, there were also significant differences in the energy intake (kcal) among children across different socio-economic classes when adjusted for age, gender and cluster of residence. Similar results showing the relationship between poor socio-economic status and poor diet quality and low dietary intakes are reported by others also (Petrauskieneet al, 2015; Shariff et al, 2015). A high energy intake of 2669±5284 kcal among 10 year old male children was reported by Elliot et al (2011) residing in Australia. According to the NSSO survey conducted in 2011-12, the total energy intake (kcal) among 7-9 year old children was 1961 kcal in rural Haryana with decreasing trends vis-à-vis the past two decades (NSSO, 2014). The study used McCrory cut-offs for estimating the measurement errors in the estimates of energy intakes (kcal) as assessed by 24-hour food and drink record method (McCrory et al, 2002). It also showed that 45 per cent of the respondents were over or under reporting the dietary intake. Widodo et al (2016) showed that the high intake of dairy foods adds substantially to the daily energy intake (kcal) among Indonesian children as was observed in the present study.

The energy intake of children significantly reduced with the decrease in socio-economic class of the household, but with a small gradient. However, literature has reported ambiguity in the relationship between the socio-economic status of the household and dietary energy intake (kcal) of the individual. These differences could be due to the difference in the availability of healthy or unhealthy foods in the neighborhood, household dynamics in the procurement of food and degree of urbanization of the place of residence (Mayen et al, 2014). Alelign et al (2015) has reported that the odds of the prevalence of underweight among 5-14 year age old children increases with an adjusted odds of 3.13 when children do not wash their hands before eating food and prevalence of anemia increases by an odds of 8.9 among those who have hookworm infection. These studies show the importance of clean environmental hygiene. Household facilities and socio-demographic characteristics were also associated with the status of under-nutrition among children. The household socio-demographic characteristics and self-hygiene indicators like "absence of toilet at home, use of untreated drinking and cooking water, bathing in river, not washing hands before eating food/after playing with animals, not washing fruits/vegetables before consumption and not wearing shoes when outside" significantly increases the odds of getting Giardiasis infection (Choy et al, 2014). The major modes of transmission of infections are through contaminated food and water resulting in fat mal-absorption and lactose intolerance (Choy et al, 2104; Buret 2008).

In the present research study, high energy intake among children (6-12 year old) could be also coupled with the high risk of morbidity since they are residing in an environment with poor living conditions and environmental hygiene indicators. The empirical data on the morbidity data was not obtained in the present research study. This cycle of adequate food intake, poor household characteristics, low socio-demographic profile, poor living conditions and lack of hygiene result in the high prevalence of thinness/severe thinness among children.

Carbohydrates (g): The median intake of carbohydrates among children (6-12 years) was 309.5 g per day. There are no RDA given for the carbohydrates and hence cannot be compared (Table 4.27 and 4.28). The median intake of carbohydrates was significantly lower among children residing in the first cluster as compared to those living in the second and third cluster. The energy per cent contribution of carbohydrates was similar across all age groups.

Table 4.28: Carbohydrate and fat intake and per cent contribution of macronutrient among children (6-12 years) in different age groups (n=293) (Median, IQR and 95% CI)

Macronutrient	6 year girls and boys (n=49)		7-9 year old girls and boys (n=144)		10-12 year old girls (n=49)		10-12 year old boys (n=51)	
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI
Carbohydrate								
Intake (g)	319.6 (248.5, 274.3)	273.9-345.5	302.0 (249.5, 380.1)	284.9-316.0	309.3 (259.6, 359.6)	248.4-341.1	333.5 (277.8, 401.7)	304.8-356.4
Energy percent (%)	58.1 (53.6, 64.6)	55.8-62.8	59.0 (52.7, 64.9)	57.4-60.4	60.4 (54.5, 65.1)	57.3-63.7	56.3 (52.0, 62.3)	54.4-59.1
Fats								
Intake (g)	66.1 (49.5, 81.8)	53.8-73.5	63.3 (47.2, 88.5)	58.9-70.5	64.0 (48.0, 75.1)	55.1-72.5	85.7 (56.6, 104.2)	73.0-95.2
Energy percent (%)	28.6 (23.2, 32.6)	25.7-30.2	28.8 (22.4, 33.4)	26.5-29.8	26.9 (20.9, 31.8)	24.6-29.3	30.8 (25.3, 35.1)	27.2-32.5

The high intake of cereals and sugars contributed to the high intake of carbohydrates among children.

Protein (g): The intake of protein (51.9 g/day) was significantly higher among children residing in the third cluster as compared to the children residing in the first and the second cluster. The intake of protein was higher across all age categories when compared with the RDA (Table 4.27 and Figure 4.13). The higher protein intake among children of the third cluster could be attributed to the popular practice of subsistence farming in the households, and consequently higher intake of milk and milk products. According to the NSSO survey conducted in 2011-12, the total protein intake (g) among 7-9 year old children was 59.4 g per day in rural Haryana with decreasing trends vis-à-vis the past two decades (NSSO, 2014). A high intake of protein was also reported among 6 year old Korean children (60.7±2.7g/d) contributing 15.2 per cent to the total energy intake (Kim et al, 2008).

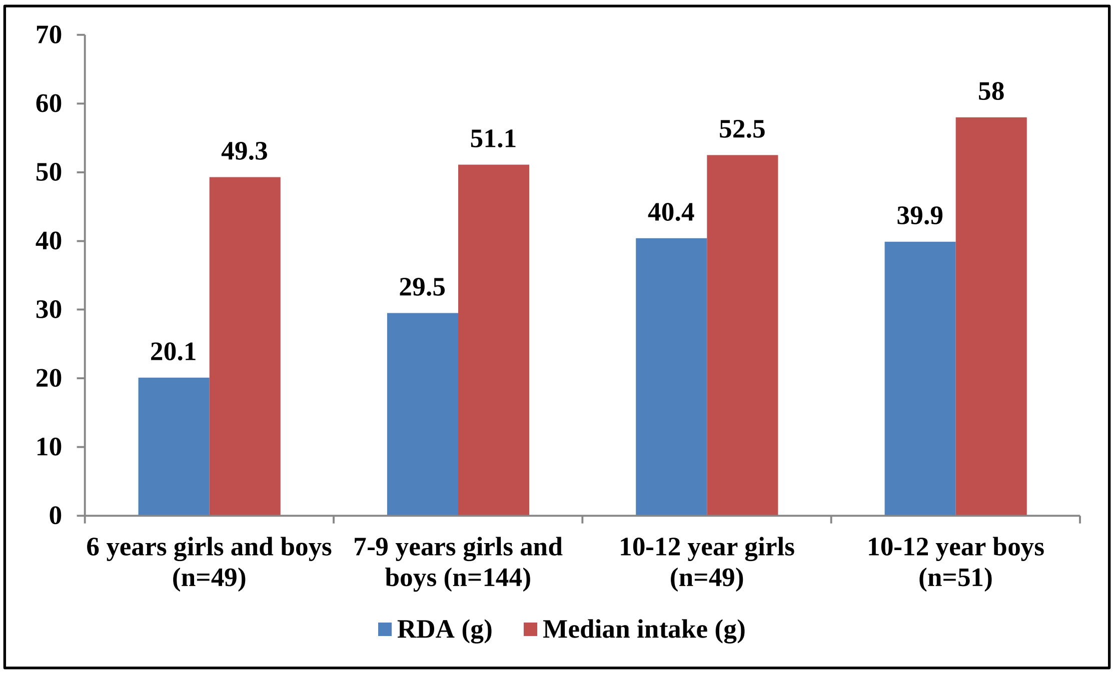


Figure 4.13: Median intake of protein and RDA among 6-12 year old children residing in three rural clusters (n=303)

Fat (g): The median intake of fat was higher among children with contribution of 28.6 per cent to the total energy intake. The energy per cent contributions of fats (visible and invisible) were significantly higher among children in the first cluster (30.6%) as compared to the children in the second (27.0%) and third cluster (28.3%) respectively (Table 4.27 and 4.28). The RDA given by ICMR (2010) as only for the visible fat intake and hence cannot be compared. The percentage contribution of fats to the total intake was similar across all age groups except a little higher among 10-12 year old boys. According to the NSSO survey conducted in 2011-12, the total fat intake (g) among 7-9 year old children in rural Haryana was found to have increased since past two decades with a mean intake of 54.5 g per day and contributing 9.0 per cent to the total energy intake (NSSO, 2014). The fat intake could be high among children across the study population because of the high intake of visible fats in the form of *ghee/boora* mixture (the traditional aspects of rural diet) and invisible fat in the form of buffalo milk. Similar results were reported among Korean children (6 year old), where the fat intake was measured by 3-day 24 hour dietary recall was reported as 47.7±2.7 gper day contributing 26.7 per cent to the total energy intake (Kim et al, 2008). These were also in concordance with the reported intakes among 6-18 girls of low socio-economic status in New Delhi (27.4% energy from fats) (Puri et al, 2008).

4.2.3.3. Micronutrient intake

The micronutrient intake (iron, thiamine, riboflavin, ascorbic acid and calcium) among children and their respective RDA in different age groups are explained in Figure 4.14. The intake of micronutrients was derived from the three day 24-hour dietary recall among children.

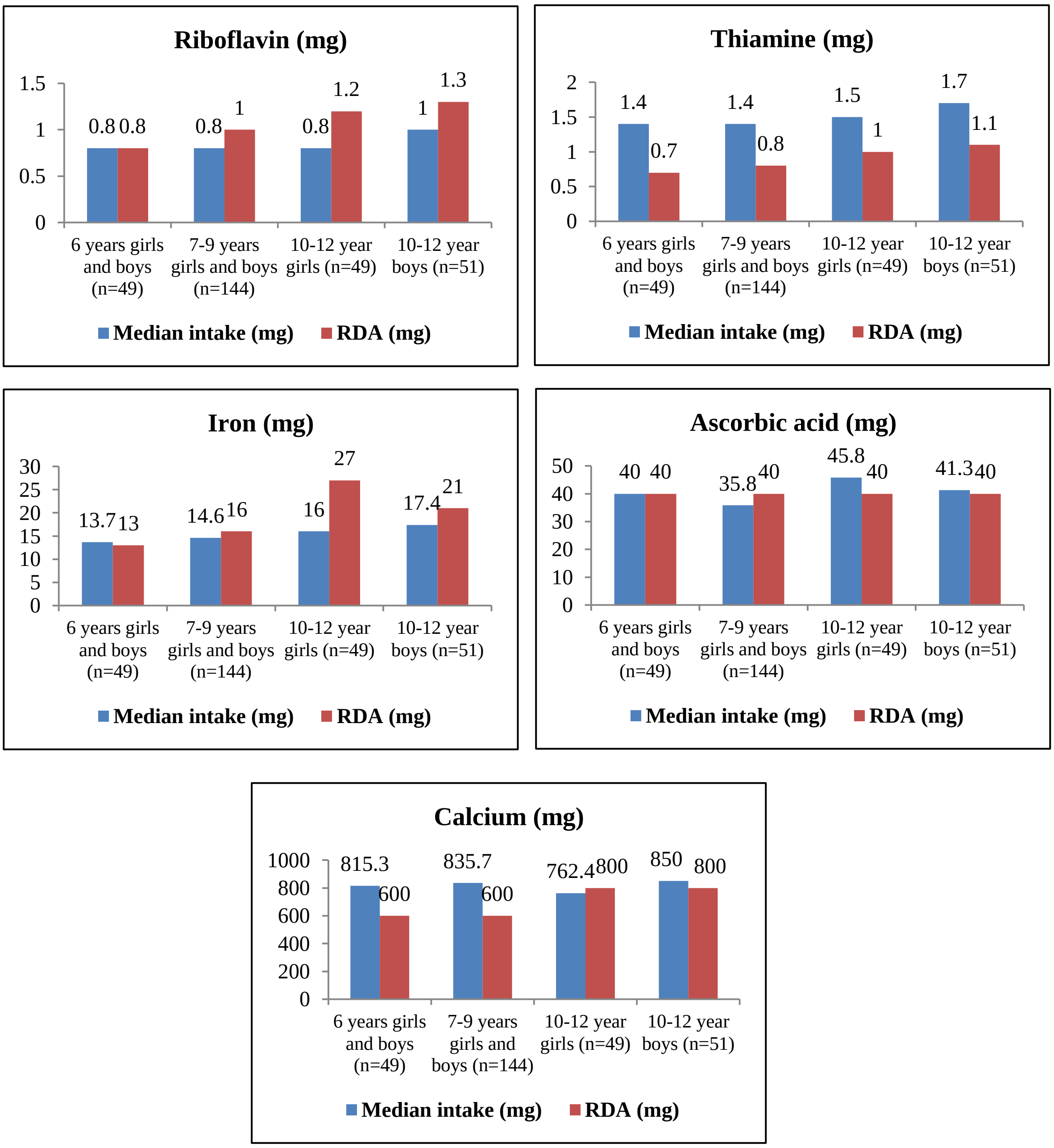


Figure 4.14: Median intake and RDA of micronutrients among children in different age categories

The median intake of iron and riboflavin was lower across all age and gender categories except 6 years girls and boys. The intake of calcium was generally appropriate and higher among younger children. This could be due to high intake of buffalo milk by the children (6-12 year old) residing in rural area. The intake of thiamine was more than the RDA across all age groups. Ascorbic acid intake matched RDA for the age.

The intake of iron, thiamine, and vitamin C were significantly different across the three clusters ($p<0.05$) as shown in Table 4.29. The intake of iron and thiamine were higher in the third cluster as compared to the other two clusters and the intake of vitamin C was significantly higher in the first cluster.

Table 4.29: Micronutrient intake (mg) among children (6-12 years) (n=293) (Median, IQR and 95% CI)[#]

Micronutrient	Cluster 1 (n=102)		Cluster 2 (n=96)		Cluster 3 (n=95)		Total (n=293)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Calcium (mg)	799.0(519.2, 1220.6)	676.6-908.6	796.1 (482.1, 1164.2)	612.4-845.9	890.3 (570.9, 1268.3)	770.9-1004.8	807.7 (516.7, 1225.6)	759.2-878.1	0.19
Iron (mg)	14.7 (11.9, 18.2)[a]	14.0-15.6	14.6 (12.2, 18.7)[b]	13.7-17.0	16.6 (13.6, 21.0)[ab]	15.2-17.8	15.2 (12.4, 18.9)	14.6-16.0	0.019
Thiamine (mg)	1.4 (1.1, 1.7)[a]	1.3-1.5	1.5 (1.1,1.8)[b]	1.3-1.6	1.6 (1.3, 1.9)[ab]	1.5-1.8	1.5 (1.2, 1.8)	1.4-1.5	0.016
Riboflavin (mg)	0.8 (0.6, 0.9)	0.7-0.8	0.8 (0.6, 1.0)	0.7-0.8	0.9 (0.7, 1.2)	0.8-0.9	0.8 (0.6, 1.0)	0.8-0.9	0.06
Vitamin C (mg)	50.5 (43.4, 60.4)[a]	43.4-60.4	28.3 (22.2, 42.2)[ab]	26.5-33.5	44.6 (29.6, 66.8)[b]	37.2-47.9	40.2 (26.2, 65.2)	36.4-44.2	0.0001

#Micronutrient intake is assessed using 3-Day 24 hour Diet recall
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) as tested by Dunn's test

Thus, despite consuming energy-rich diet by the children (6-12 year old) the children, there was a high prevalence of thin/severe thin children across the three rural clusters. In addition, the median energy intake (kcal) among children did not reflect any cluster level differences; however, there were differences in the percentage contribution of different macronutrients to the median energy intake across three rural clusters.

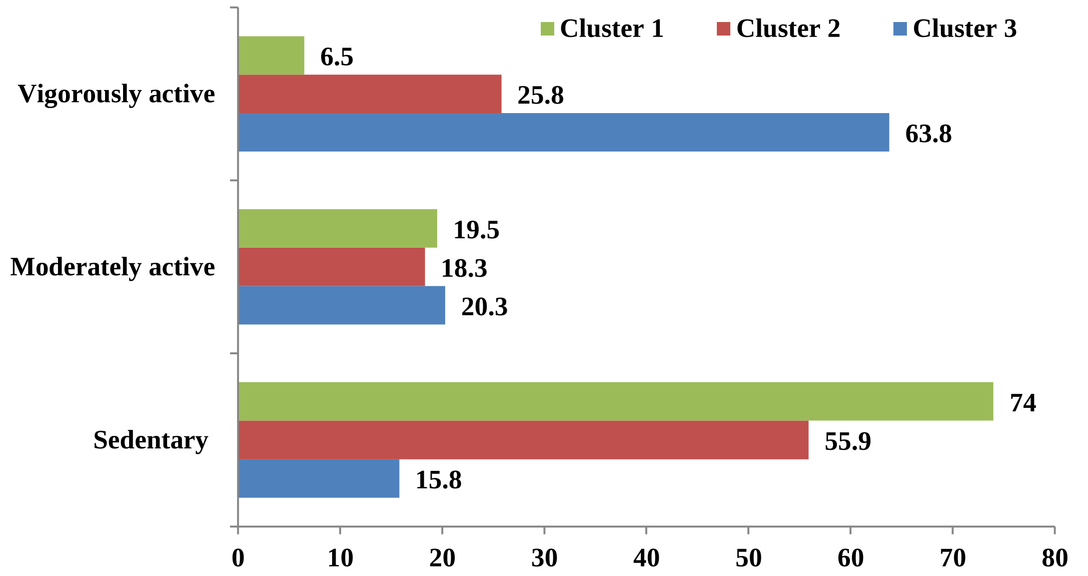
4.2.4. Physical Activity Profile and Sleep Behavior of Children (6-12 years)

The physical activity profile of the sampled children (6-12 years old) was assessed in terms of “met minutes of the activity” and “Physical Activity Level (PAL)”.And the sleep behavior among children was assessed in terms of sleep duration and sleep problems.

4.2.4.1. Physical Activity Profile of Children (6-12 year old)

Figure 4.15 and Table 4.30 represent the physical activity profile of the selected children (6-12 years) residing in the three rural clusters. The children residing in the third cluster had significantly ($p<0.05$) higher met minutes of total physical activity (3091.9) as compared to those in the first (2246.2) or second (2566.4) cluster respectively. In addition, when categorized according to the PAL, almost three-fourth of the children in the first cluster (73.8%) had a sedentary lifestyle; significantly higher as compared to the children residing in the second (43.8%) and third (15.0%) cluster. Nearly two-third of the children in the third cluster were vigorously active (65.5%). These differences could be due to the fact the population density of the third cluster was very low, which in turn provided ample space for children to play as compared to children residing in denser areas (the first and second cluster). The significant differences in the physical activity profile of the children in three rural clusters showed that the location of residence has an influence on the physical activity behavior of children.

The median PAL among the children (6-12 year old) in the current study sample was 1.8, which is higher than the mean PAL of 1.4 among 6-9 year old normal children reported by Kapil and Bhadoria (2013). The rural children in this district appeared to be active and engaged in lot of activity. Gulati et al (2014) reported the prevalence of sedentary behavior among children as 21 per cent across 7 different cities of India. Within the three clusters, sedentary behavior varied vastly and indicates that local built environment and population level factors might be contributing to the physical activity pattern of children (Santos et al, 2009; Tester and Baker, 2009; Sallis and Glanz, 2006).



** PAL is defined as the ratio of total met minutes of activity and total duration (minutes) in 24 hours. FAO/WHO/UNU cut-off points were used to categorize PAL*

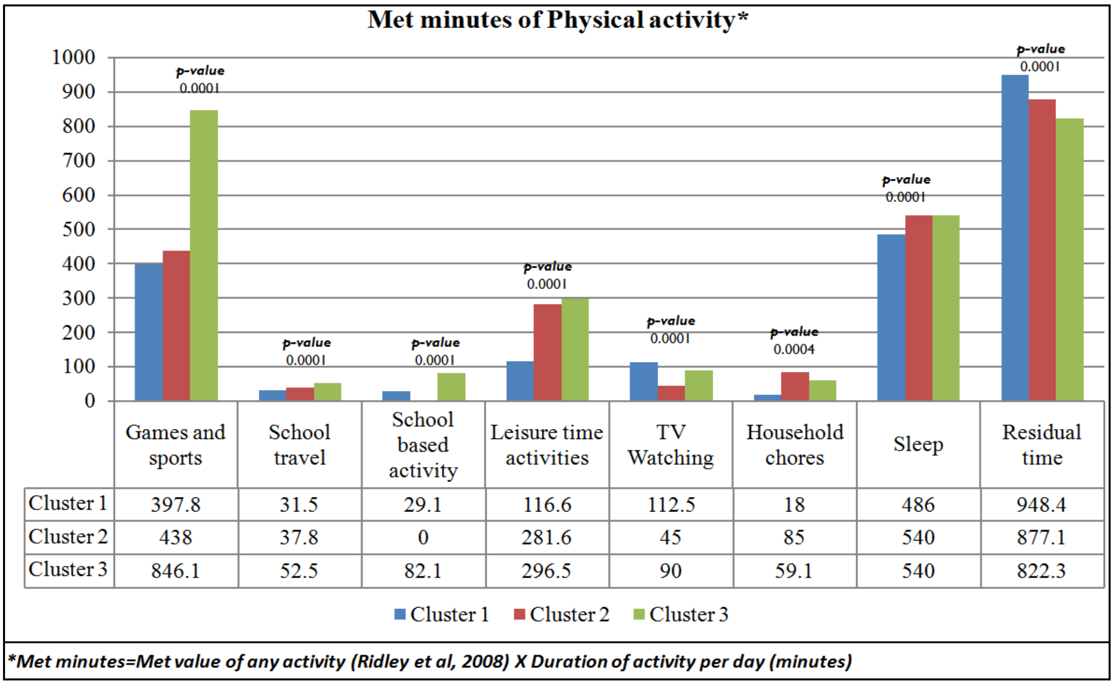
Figure 4.15: Distribution of children (6-12 year old) according to their Physical activity levels (PAL) residing in three rural clusters

Table 4.30: Total met minutes among children (6-12 years) (Median, IQR and 95% CI)$^{\#}$

Physical activity indicator	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Total met minutes	2246.2 (2041.4, 2489.3)^{de}	2192.3-2300.4	2566.4 (2244.4, 2996.4)^{df}	2432.9-2677.9	3091.9 (2702.1, 3520.6)^{ef}	2975.0-3229.5	2569.7 (2206.6, 3066.4)	2481.9-2638.6	0.0001

#Met minutes=Met value of any activity (Ridley et al, 2008) X Duration of activity per day (minutes)
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences between the groups (p<0.05) and (d/e/f) represents the significant differences (p<0.0001) as tested by Dunn's test

Although the median met minutes of a cluster were not associated with prevalence of the thinness, the high levels of physical activity in general among study children could be contributing to the thinness of the children observed in spite of having a high caloric diet. In this rural community, it was observed that the children (6-12 year old) were highly engaged in unstructured activity (like climbing a tree, running with tyre, playing in sand, walking here and there etc.) which was not accounted by the physical activity questionnaire used in the study and these were assigned to residual time. Therefore, the total duration of residual time was very high across three clusters. The physical activities captured in the current study were specific to the rural community and hence, the met values used for calculating met minutes were taken for the nearest possible activity as per the definitions. The Met values (Metabolic equivalents) of various physical activities (as captured by the questionnaire) given by Ridley et al (2010) were used to calculate the met minutes. This compendium was prepared and revised on the basis of the comprehensive compendium of physical activities and their metabolic equivalents for adults given by Ainsworth et al (2011).



	Games and sports	School travel	School based activity	Leisure time activities	TV Watching	Household chores	Sleep	Residual time
Cluster 1	397.8	31.5	29.1	116.6	112.5	18	486	948.4
Cluster 2	438	37.8	0	281.6	45	85	540	877.1
Cluster 3	846.1	52.5	82.1	296.5	90	59.1	540	822.3

Figure 4.16: Met minutes of physical activity in various categories done by children (6-12 year old)

There were also significant differences ($p<0.05$) in the physical activity profile of children (6-12 year old) across three rural clusters with respect to the various categories of physical activities done by the child (Figure 4.16). Figure 4.17 shows various physical activities in which children were engaged in rural community. The met minutes of residual time/TV watching were higher among the children residing in the first cluster; leisure time activities/household chores/sleep duration was higher among the children residing in the second cluster; and the school based activity/games and sports/leisure time activities/sleep duration was higher among children residing in the third cluster. The duration of school-based activities spent by the child was very less.

This could be due to lack of a sports instructor and equipment's at most of the schools. This difference in the physical activity profile of the children could be due to the difference in the availability of facilities at home, socio-economic conditions, demographic factors, opportunities provided for physical activities at school, neighborhood level built environment as discussed in section 1 (Oreskovic et al, 2015; Hardman 2008).

Figure 4.17: Physical activities in which children are engaged

The total met minutes of the physical activity incurred by children (6-12 year old) was inclusive of the activities done on weekdays and weekends. The analysis was not done for weekday and weekend in separation. However, a study conducted among Portuguese children (n=686) showed that that during weekdays the MVPA (Moderate-to-Vigorous Physical Activity) was higher as compared to the weekends and also significantly different between males and females and children with different nutritional status (BMI-for-age) (Pereira et al, 2015).These differences in physical activity levels were also dependent on the school environment and neighborhood built environment for physical activity (Oreskovic et al, 2015; Hardman 2008). Similar results were reported by Mieglo-Ayuso et al (2016) among 9-11 year old Spanish children where the children found to be spending 616.6±578.6 minutes per week in moderate to vigorous physical activity.

The other factor which influences the physical activity profile of children includes age, sex and socio-economic profile of the households. There were significant age and gender adjusted differences in the physical activity profile of children as assessed in the current study sample (6-12 year old children) with boys being more active than girls.

The age and gender differences among children in the same age group have been documented by other researchers also, wherein, girls were found to be less active than boys (Mieglo-Ayuso et al, 2016; Gulati et al, 2014).

बच्चे खेल, दौड़-भाग में रह जाते हैं। इन पर घर भी वो ही काम है।
मम्मी-पापा के साथ खेत पर चले गए। हमारी कई बिटियां
tractor भी चलाती हैं।
क्योंकि घर में
कोई चीज़ होती है तो बच्चा सीख ही जाता है। कई बिटिया बिजली के काम
भी कर लेती हैं।
ये बिटियां 4 किलोमीटर पैदल जाती हैं। तो फैट बढ़ने का मतलब ही नहीं है।
मै बच्चों को आते ही कसरत करने के लिए कहता हूँ।
शहरों में तो बच्चे बार-बार मुँह
चलाते-रहते हैं।
इस चीज़ पर प्रतिबंध होना चाहिए। जो बच्चा काम नहीं करेगा,
वो बच्चा मोटा होगा।

(School teacher, Government school, Cluster 3)

The total met minutes of physical activity undertaken by the child was significantly higher among children who belonged to poor households (2697.1 met minutes) as compared to rich households (2433.3 met minutes) (p-value: 0.000; 95% CI: 27.9-264.1) and residing in the third cluster (p-value: 0.015; 95% CI: 740.0-964.6) when adjusted for the cluster of residence and socio-economic status. Similar differences in the physical activity patterns according to the differences in the socio-economic status in rural areas have been documented by Cottrell et al (2015) and Micklesfield et al (2014), wherein, the children belonging to low socio-economic status were significantly engaged in higher MVPA (Moderate-to-Vigorous Physical Activity) (Micklesfield et al, 2014).

The differences in the physical activity profile of children (6-12 year old) could also be due to the differences in the reference period of measurement and assessment. The reduction of total MVPA and increasing sedentary behavior during rainy season as compared to the dry days has been documented in the literature in a cohort of 9-14 year old children (Harrison et al, 2015). Although in the present study, the physical activity assessment of children was not done during vacations considering the difference in physical activity patterns of children during holidays and working days (Pereira et al, 2015). The physical activity assessment among children in the current study had some limitations. These include the use of questionnaire-based method for assessing the physical activity of children (6-12 year old). Thus, energy expenditure (kcal) could not be estimated and hence the equation of energy balance cannot be tested. The second limitation was the lack of Met values (Metabolic Equivalents) for various types of physical activity among Indian children.

4.2.4.2. Sleep Behavior of Children (6-12 year old)

The sleep behavior among the children (6-12 year old) was assessed in terms of the total sleep duration and sleep problems. There were significant differences in the total sleep duration of the children (6-12 year old) residing across three rural clusters. The children in the first cluster had significantly less duration of total sleep (540 minutes) as compared to the total sleep duration among the children residing in the second (600 minutes) and third (600 minutes) cluster respectively (Table 4.31).There were no age and sex adjusted differences in the total duration of sleep among children (6-12 year old) in the current study. The sleep duration in the study sample was also classified according to the cut-offs given by Cappuccio et al (2010) for defining the short sleep and long sleep. It was found that 13.2 per cent of the children (6-12 year old) had short sleep (less than 8 hours) and 86.8 per cent had long sleep (more than 8 hours of sleep). Among Indian children the mean duration of sleep has been reported as 8.77±0.80 hours by Bharti et al (2006).

Table 4.31: Total sleep duration among children (6-12 years) (Median, IQR and 95% CI)[@#]

Physical activity indicator	Cluster 1 (n=200)		Cluster 2 (n=191)		Cluster 3 (n=177)		Total (n=568)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Sleep duration (minutes)	540 (510, 600)[de]	540-570	600 (540, 660)[d]	600-600	600 (540, 660)[e]	600-600	600 (540, 660)	600-600	0.0001

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e/f) represents the significant differences ($p<0.0001$) as tested by Dunn's test

In the current research study, when adjusted for BMI there were significant differences in the total duration of sleep. It was found that with the increase in BMI of children by one unit, there was a decrease in the duration of sleep by 6 minutes. Similar results were reported by a meta-analysis in a sample of 2-20 years children (Cappuccio et al, 2008). The reduced sleep duration increases the risk of a higher BMI and thus, resulting in childhood obesity. Lower duration of sleep also significantly increased the odds of getting overweight/obese (Ping et al, 2012). Despite the low prevalence of overweight and obesity in the current research study (3.0%), the duration of sleep in overweight and obese children was significantly shorter (22 minutes) as compared to normal children after adjusting for cluster differences.

In the present study, the regression analysis revealed that the reduction in visible fat intake and increase in the total met minutes of the physical activity significantly increases the duration of sleep among children (6-12 year old). However, the unit of decrease or increase was found to be very small. Similar results of the influence of sleep behavior on diet were reported across pediatric population (Patel et al, 2008; Chen et al, 2008).There were no significant associations of the other dietary variables with the total duration of sleep among children in the current study. There were no significant differences in the various sleep problems among the study sample (6-12 year old children) residing across three rural clusters.

4.2.5. Eating Pattern Phenotypes of Children (6-12 years)

The eating pattern phenotypes were assessed to study the sensitivity to reward and restraint phenotype among children (6-12 year old). The differences in the phenotypic behavior of the children are assumed to have influence on the dietary pattern and consequently health status of the child. The sensitivity to reward phenotype was assessed using the Behavioral Activation Scale/Behavioral Inhibition Scale (BIS/BAS Scale). The tool was developed to assess the "aversive motivational system (BIS) and appetitive motivation (BAS) among children (Carver and White, 1994). The restraint phenotype among children was assessed using the Dutch Eating Behavior Questionnaire which was validated among 7-12 year old children (van Strien and Oosterveld, 2008). The questionnaire assessed three aspects of eating behavior among children including restraint eating, external eating and emotional eating.

4.2.5.1. Restraint Phenotype

There were no differences in the proportional scores of the restraint eating among children (6-12 years across three clusters). The median proportion of the external eating score of the total eating behavior score among children (6-12 year old) was found to be significantly higher among children of the second cluster (Table 4.32). The proportional scores of the restraint behavior was the least of the total eating behavior score with no significant differences among groups of children. The children residing in the first cluster had significantly higher proportional scores of emotional eating and significantly lower external eating scores as compared to the children residing in the second and third cluster.

Table 4.32: Scores of different eating pattern phenotypes among children (6-12 years) (Median, IQR and 95% CI)

Eating behavior characteristic	Cluster 1 (n=199)		Cluster 2 (n=190)		Cluster 3 (n=174)		Total (n=563)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Restraint phenotype									
Restraint eating (%)	22.2 (18.3, 24.3)	20.5-22.7	21.3 (19.6, 23.8)	20.8-21.8	21.3 (20.0, 22.7)	20.8-21.7	21.3 (19.6, 23.8)	21.3-21.7	0.87
External eating (%)	41.5 (38.2, 43.9) [de]	40.4-42.2	51.1 (43.9, 54.5) [d]	49.1-52.1	50 (46.5, 53.1) [e]	50-51.0	46.5 (41.5, 52.1)	45.2-47.7	0.0001
Emotional eating (%)	36.4 (33.3, 40.9) [de]	35.4-37.5	28.3 (25.5, 31.7) [d]	27.3-28.9	28.3 (26.5, 30.2) [e]	28.3-28.9	30.4 (27.1, 35)	29.8-31.0	0.0001
Sensitivity to reward phenotype									
Behavioral activation score (BAS Score)[$]	52 (48, 55) [d]	51-52	51 (46, 55) [e]	50-52	39 (33, 46.5) [de]	37-40	49 (40, 53)	48-50	0.0001
Behavioral Inhibition score (BIS Score)	26 (24, 28) [de]	26-26	24 (21, 27)[ef]	23-25	19 (16, 22)[df]	18-20	23 (19, 26)	23-24	0.0001

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences (p<0.05) and (d/e/f) represents the significant differences (p<0.0001) as tested by Dunn's test
$Total BAS score includes scores of fun-seeking, drive and reward restraint components

The external eating behavior signifies the response to external eating cues available in our environment in the form of sensory aspects of foods like aroma and taste, availability of food in the neighborhood. The eating behavior among children was measured using Dutch Eating Behavior Questionnaire, which was validated among 7-12 year old children (van Strien and Oosterveld, 2008). The study showed that a higher score of external eating was associated with the higher consumption of unhealthy foods especially among girls (Banos et al, 2011; van Strien and Oosterveld, 2008).

4.2.5.2. Sensitivity to Reward Phenotype

The behavioral activation score describes the degree of appetitive stimuli among children (6-12 year old). The total BAS score of children residing in the third cluster was significantly lower as compared to the first and second cluster (Table 4.32). In addition, there were no differences in the overall BAS score of the children (6-12 year old) when adjusted for age, gender and mean energy intake (kcal). However, the higher intake of unhealthy food among children (6-12 year old) was significantly related to the total BAS score among children when adjusted for age and sex. The external environment with variety of food cues has been documented to be significantly related with the reward sensitivity and caloric intake among children (Pacquet et al, 2010; Jansen et al, 2008). Guerrieri et al. (2008) investigated that children who do not have weight problems yet are also more sensitive to the diverse food environment surrounding them representing a higher degree of appetitive stimuli. The individuals with high BAS levels were more reward sensitive exhibiting high levels of impulsivity. The differences in the BAS score among three clusters reiterate that the environmental cues are associated with the reward seeking behavior. The BIS score was found to be significantly lower among children residing in the third cluster as compared to the children in other two groups.

4.2.6. Household Food Environment of Children (6-12 years)

The method of household food inventory is validated to study the relationship between the household food availability and dietary intake of children (Ihmels et al, 2009; Wilson et al, 2007; Fulkerson et al, 2008; Popkin et al, 2003). The household level food availability and purchase behavior is assumed to have an influence on the dietary intake of the children. The method of household food inventory used to assess the food availability in the current research study showed that there were significant differences in the availability of food items in the households of three rural clusters. These differences in food item availability were measured in terms of "food groups". The household where the assessment was done implies those households where the child (6-12 years old) recruited for the study resides.

4.2.6.1. Household Food Availability

The food availability of different food groups is significantly different among the households in three rural clusters. The per capita monthly availability of pulses and legumes (366.7 g), milk and milk products (11.9 kg) and fruits and vegetables (5.2 kg) was significantly higher in the households in the first cluster as compared to the households in second and the third cluster. However, on the other hand the per capita monthly availability of meat, fish and poultry (64.3 g) and unhealthy foods (1187.2 g) was found to be significantly higher among the households in the second cluster (Table 4.33).

Table 4.33: Per capita availability of various food groups in the households of children (6-12 years) (Median, IQR and 95% CI)[#]

Food groups	Cluster 1 (n=96)		Cluster 2 (n=92)		Cluster 3 (n=93)		Total (n=281)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Cereals (kg)	8.1 (5.6, 10.7)	7.5-9.0	7.4 (4.5, 13.0)	6.3-9.7	7.8 (6.0, 9.7)	7.4-8.3	8.0 (5.7, 10.8)	7.5-8.4	0.95
Pulses (g)	423.9 (282.4, 704.5) [ab]	366.4-535.8	339.3 (200.1, 506.0) [a]	275.3-419.4	318.8 (131.6, 546.4)[b]	207.0-379.8	366.7 (186.4, 595.0)	323.6-400	0.006
Milk & milk products (kg)	14.0 (6.6, 26.7)[d]	10.8-17.6	7.5 (2.3, 15.4)[de]	4.6-10.8	12.7 (6.4, 24.8)[e]	10.3-18.1	11.9 (4.6, 21.3)	9.8-13.5	0.0001
Meat, fish and poultry (g)	0 (0, 0)[d a]	0-0	64.3 (0, 565.6)[db]	0-349.4	0 (0, 341.7) [ab]	0-0	0 (0, 250)	0-0	0.0001
Fruits and vegetables (kg)	6.0 (4.5, 8.6)[d]	5.4-7.0	4.1 (2.8, 5.6) [ad]	3.7-4.6	5.3 (4.3, 6.9) [a]	4.8-5.7	5.2 (3.8, 7.1)	4.7-5.5	0.0001
Fats and oils (g)	551.1 (402.8, 841.3)	516.9-662.7	482.2 (295.4, 784.4)	419.0-545.6	440.0 (271.9, 716.7)	370.9-562.0	500 (295.0, 795.8)	461.7-546.1	0.07
Sugars &its products (g)	2213.7 (1094.2, 3147.2)	1794.3-2461.1	2135.4 (1357.4, 2943.3)	1958.9-2412.8	1915 (1197.2, 3454.2)	1678.3-2316.8	2100.0 (1267.5, 3113.2)	1920.6-2272.2	0.87
Total unhealthy food (g)	828.7 (455.1, 1182.6)[ab]	614.0-992.5	1187.2 (620.6, 2003.8)[ad]	939.1-1475.7	519 (293.1, 905.6)[bd]	438.7-676.0	769.4 (446.9, 1371.1)	664.3-922.3	0.0001
Sweets and confectionaries (g)	286.2 (114, 662.3)[ab]	209.1-364.6	189.4 (39.9, 387.0)[a]	123.9-263.1	167.9 (29.2, 412.5)[b]	85.8-219.1	208.9 (49.5, 514.4)	168.5-250.0	0.0033
Salty and fried snack (g)	127.3 (52.7, 268.2)[a]	104.1-146.0	161.3 (45.5, 256.5)[b]	103.1-189.8	85.8 (35.8, 166.9)[ab]	68.9-110.3	116.7 (44.3, 240.3)	95.6-135.0	0.03
Bakery products (g)	105 (57.7, 220.8)[d]	79.9-137.8	263.6 (92, 649.2)[de]	171.1-341.6	117 (33.3, 304.2)[e]	63.1-142.8	135.7 (56.7, 357.1)	114.3-168.7	0.0001
Beverages (g)	79.6 (35.4, 159.8)[da]	60.1-102.6	205.6 (66.6, 827.1)[de]	115.1-432.1	39.5 (17, 104.2)[ea]	28.3-57.2	80 (32.1, 208.3)	68.4-95.6	0.0001

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0001$) as tested by Dunn's test

#The per capita availability of different food groups includes the total availability from all sources i.e., self produce, farms/fields, market purchased, received as gifts from neighbors or relatives, any government program (ICDS/MDM) or procured through barter.

These differences could be due to not only the differences in the socio-economic and socio-demographic characteristics of the household but also due to the differing community food environment in the three rural clusters; primarily Hindus in the first cluster and Muslims in second cluster and mixed population in third cluster. The availability of pulses and legumes, fruits and vegetables and milk/milk products in the households was significantly higher when adjusted for the socio-economic class of the household. However, the availability of fats and oils and sugars did not change with the socio-economic status of the household. This shows that sugars and fats were an essential component of the dietary behavior of this rural settings considering the high intakes of these two food groups among children (6-12 year old) residing in these households. The per capita availability of cereals, pulses, milk, across the nation was 444.1 g/d, 47.2 g/d, 307g/d, respectively (MoA, 2014). This showed that the national availability of different food groups in the household were much lower as compared to the availability reported in the present study. However, the per capita availability of milk is 800g/day in the Haryana state which was higher than the reported availability of milk and milk products in the present study.

The availability of the unhealthy food categories did not differ significantly with the change in the socio-economic class of the household. The availability of bakery products (biscuits/breads/fan) was significantly higher in the poor households (241.8 g) (p-value: 0.001; 95% CI: 88.4-352.5) as compared to rich households (97.5g) and those in second cluster (p-value: 0.000; 95% CI: 107.0-285.1) with similar adjustment. The availability of salty fried and packaged snacks and sugar sweetened beverages significantly differed across clusters but no significant differences were found when adjusted for the socio-economic status of the household. This showed that the cost of the food item was essential in governing the availability of the food product in the household. Bakery products being cheaper in price act as ready to eat foods and replace the meal in the poor households, whereas, sweets and confectionaries being expensive (except toffee and sweet imitates) adds to the additional calories in the daily diet. This was reiterated by the fact that the total dietary energy intake (kcal) was significantly lower in poor household (2042 kcal) vis-à-vis the rich households (2252 kcal) (p-value: 0.016; 95% CI: -428.5 to -43.8). The availability of different food items across the three rural clusters could also be affected due to the differences in the reference period for data collection. Since different seasons like winters, summers, rainy seasons imposes different nutritional requirements and different food choices among population (Hillbruner and Egan 2008).

4.2.6.2. Household Food Purchase Behavior

The food purchase behavior of the household is defined in terms of the purchase frequency (Table 4.34) and the money spent on the market purchase of the household (Table 4.35). The market purchase frequency of healthy foods was found to be significantly lower in the households of the first cluster (81.5 times per month) as compared to the second cluster (93 times per month) and third cluster (96 times/month) respectively. On the other hand, the market purchase frequency of unhealthy foods was significantly higher in the households of the second cluster (44.5 times/month) as compared to the first (27.5 times/month) and third cluster (30 times/ month) respectively.

Table 4.34: Frequency of purchase of various food groups in the households of children (6-12 years) (Median, IQR and 95% CI)

Food groups	Cluster 1 (n=96)		Cluster 2 (n=92)		Cluster 3 (n=93)		Total (n=281)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Total market purchase frequency/day	2.8 (2.0, 3.7) [d]	2.5-3.3	3.9 (3.0, 5.1) [de]	3.6-4.3	2.8 (1.9, 4.2) [e]	2.5-3.3	3.3 (2.3, 4.2)	3.0-3.4	0.0001
Total healthy food/ month#	81.5 (71, 98) [ad]	76-87	93 (79, 104.5) [a]	87-98	96 (80, 115) [d]	92-104.5	90 (74, 106)	87-94	0.0003
Total unhealthy food/ month##	27.5 (18, 42.5) [d]	22.9-32	44.5 (30.5, 76) [de]	38-54.8	30 (18, 46) [e]	26-36	33 (21, 50)	30.6-37	0.0001
Sweets and confectionaries/ month	5 (3, 9) [ab]	4-6.0	8 (3, 17) [a]	5-11.4	7 (3, 12) [b]	5-10	6 (3, 12)	5-7	0.007
Salty and fried snacks/month	10 (5, 16)	7-12.4	10 (6, 27.5)	8-17.5	9 (4, 15)	6.5-10	9 (5, 19)	8-11	0.07
Bakery products/Month	7 (3, 12) [a]	6-9	12 (6, 24) [ab]	9-15	6 (3, 15) [b]	4-9	8 (4, 18)	7-9	0.0002

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0001$) as tested by Dunn's test
#Healthy food groups include pulses and legumes, milk and milk products, fruits and vegetables, fats and oils, sugars, dry fruits.
##Unhealthy food group include sweets and confectionaries, salty and fried snacks, bakery products and beverages.

Table 4.35: Money spent (INR) in market purchase of various food groups in the households of children (6-12 years) (Median, IQR and 95% CI)

Food groups	Cluster 1 (n=96)		Cluster 2 (n=92)		Cluster 3 (n=93)		Total (n=281)		p-value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Cereals	65 (35, 140)	44.6-81.7	106.5 (50, 170)	72.8-126.9	60 (30, 335)	36.7-114.6	76.5 (40, 175)	60-99.7	0.38
Pulses	115 (55, 225)[a]	87.2-157.8	107.5 (60, 192)[b]	90-145	78 (45, 135)[ab]	65-110	105 (55, 175)	89.8-120	0.02
Milk and its products	781.5 (490.5, 1320)	637.0-1237.4	615 (200, 900)	395.6-722.9	675 (348, 1169)	452.4-1105.3	671.5 (330, 1240)	596.3-782.1	0.08
Fruit and vegetable	633 (484, 825)[a]	556.4-694.3	777.5 (574, 1019)[ab]	716.9-834.6	677 (460, 917)[b]	610.1-757.5	701.3 (494, 912.5)	661.1-743	0.03
Sugar	389 (241.5, 578.5)[a]	335.6-454.4	556 (375.5, 740)[ab]	482.2-614.9	377 (162, 772)[b]	286.3-424.2	441.5 (265.5, 698)	391.7-500.0	0.002
Fats and oils	250 (170, 580)	210.7-400	230 (120, 460)	160-306.0	205 (120, 360)	172.5-242.5	240 (147.5, 500)	200-262.6	0.07
Dry fruits	160.5 (63, 317.5)[ab]	101.9-213.1	52.5 (30, 175)[ac]	37.7-124.2	102.5 (40, 180)[bc]	70-136.1	107.5 (40, 227.5)	80-135.2	0.001
Sweets &confectionaries	110 (35, 235)	81.9-159.6	107.5 (47, 240)	76.2-166.8	70 (26, 200)	44-145	100 (34, 223)	81.4-130.4	0.11
Salty and fried snacks	95 (54, 159)[a]	75.6-125	110.5 (54, 210.5)[b]	85.5-136.6	76 (30, 145)[ab]	56.0-93.4	92 (48, 159.5)	78.9-107	0.04
Bakery products	59 (30, 113)[a]	45-70.7	130 (45, 290)[ab]	83.9-164.7	50 (22, 138)[b]	35-85	65 (30, 168)	55-85	0.0001
Beverages	145 (80, 265)[ab]	120-180.2	170 (95, 330)[ad]	140-231.5	90 (40, 160)[bd]	60-120	140 (62, 270)	120-160	0.0001

*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b/c) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0001$) as tested by Dunn's test

However, there were no significant differences in the market purchase frequency of the households when adjusted for their socio-economic status (Table 4.34). The higher purchase frequency of unhealthy foods in the second cluster could be due to the fact that the second cluster was situated on the national highway and had easy access to and greater availability of unhealthy foods in the surrounding area. The differences could also be due to the differences in the source of procurement of the food item. In the first and third cluster, the unhealthy foods were procured from the food stores/market (part of the community food environment surrounding the household) and also received as gift from neighbors or relatives. However, in the second cluster these were majorly procured from the market. In addition, the household level monthly availability of sweets and confectionaries was lower in the second cluster, whereas, the purchase frequency is significantly higher in the second cluster. This showed that in the second cluster, food items in the category of sweets and confectionaries were purchased more frequently but of smaller portion sizes (toffees and candies, sweet imitates).

There were differences in the money spent on the food groups among the households of children (6-12 year old) residing in three rural clusters (Table 4.35). The money spent on market purchase of fruits and vegetables and sugar and sugar products was found to be significantly higher among the households of the second cluster as compared to the first and second cluster. This could be attributed to the high population density (persons/sq.km.) of the second cluster which has resulted in less space for agriculture and allied farming activities. Thus, reliance on market purchase of household food items had increased as compared to other sources of procurement. Other sources of procurement includes self-produced, from farms/fields, received as gift/loan from relatives/neighbor. The households in the third cluster (216 INR/month) spent significantly less on the unhealthy food (salty and fried snacks, bakery products and beverages) as compared to the households in the first (299 INR/month) and second cluster (410.5 INR/month) respectively. However, there was a wide variability in the money spent on unhealthy foods among the households of the second cluster. This variability could be due to the difference in the proportion of different socio-economic class among the recruited households of the second cluster. In India, the households of rural India spend 53.9 per cent of their total income on the food, where the maximum share is on cereals (18%) (NSSO, 2004).

4.2.7. Neighborhood environment assessment of the recruited sample (6-12 year old)

4.2.7.1. Built Neighborhood Environment

The neighborhood level built environment is an essential characteristic governing the physical activity among the population residing nearby. The built environment in the current study was quantitatively assessed, where the buffer zone for the built environment around the household was taken as "500 meters". These households are those where the study sample of 6-12 year old children resides. Table 4.36 reflects the significant differences in the distribution of households in the three rural clusters according to the perceived response of the different built environment attributes in their neighborhood.

Table 4.36: Attributes of the neighborhood built environment as perceived by the households of children (6-12 year old)#

Built environment indicators	Cluster 1 (n=102)	Cluster 2 (n=98)	Cluster 3 (n=94)	p-value
Density and land use				
High density	77 (75.5)	45 (45.9)	53 (56.4)	0.000^
Landuse$	61 (59.9)	90 (91.9)	75 (79.8)	0.000^
Infrastructure and aesthetics				
Poor condition of streets	102 (100.0)	83 (84.7)	70 (74.5)	0.000^
Water on streets during rain	92 (90.2)	76 (77.5)	68 (72.4)	0.004*
Poor aesthetics	96 (94.1)	80 (81.6)	74 (78.7)	0.003^
Safety indicators				
Presence of traffic calming devices	83 (81.4)	88 (89.8)	63 (67.0)	0.000^
No safety area while walking	101 (99.0)	47 (48.0)	49 (54.2)	0.000^
Fast and moderate traffic flow	100 (100.0)	70 (71.4)	71 (75.6)	0.000^
Safety for cycling	6 (5.9)	69 (70.4)	42 (44.74)	0.000^
Not safe from stray animals	101 (99.0)	57 (57.1)	52 (55.3)	0.000^
Indicators describing proximity to services				
Presence of transit stops	63 (61.8)	77 (78.5)	64 (68.1)	0.03^
Proximity to general services	97 (95.1)	71 (72.5)	62 (66.0)	0.000^

Neighborhood built environment: buffer zone 500 meters
$Land use in terms of residential, commercial and agricultural
*p-value estimated using chi-square test
^p-value estimated using fisher's test
Figures in parenthesis denote percentages

Figure 4.18: Different attributes of built environment in the study site

The different sub-components of the built environment include density and land use, pedestrian infrastructure, bicycling infrastructure, roads and parking, trails, transit facilities, safety, aesthetics and character and proximity to services. The households in the first clusters perceived their neighborhood as highly dense with poor infrastructure and aesthetics, unsafe from high flow of traffic and stray animals as compared to the second and the third cluster. These differences in the built environment characteristics of the neighborhood environment could be varying due to the differences in the socio-economic profile of the community, different living conditions and environmental hygiene characteristics. There was a proportionate decrease in the total built environment score according to the socio-economic status of the sampled households, however not significant. The overall score of the built environment including all the attributes studies was not found to have any significant relationship with the physical activity levels of children. Figure 4.10 represents various built environment attributes in the neighborhood of the sampled household.

The structured built environment and facilities are associated with the increased levels of physical activity among children (Colabianchi et al, 2009; Santos et al, 2009). The built environment also enhances the active commuting among children and is thus associated with physical activity among children (Bungum et al, 2009; Hume et al, 2009). In the present study, 69.4 per cent of the children (6-12 year old) were using active mode of transportation (walking/bicycling) for commuting to school and 30.6 per cent of the children were using passive mode of transport (car/bus/van). There were significant differences in the active commuting to school across male and female children residing in three rural clusters. But the barriers to active commuting were traffic safety, pedestrian infrastructure, population density, gender, street connectedness and peer group in an area. Neighborhood crime and safety plays an important role in the reduction of walking or physical activity, especially among children. Conversely, those who live in areas with more trust or "social cohesion" tend to have higher levels of physical activity (Sallis et al, 2006).

4.2.7.2. Community Food Environment

The community food environment is an indicator of the economic growth and is a functional lever for catalyzing the availability of foods in the households and hence consumption of the population. The community food environment of the three rural clusters sampled in the current research study is described below in Tables 4.37-4.39. The typology of stores present in the community food environment of the three rural clusters is explained in Table 4.33. Of all the food stores mapped (n=382) and assessed in the three rural clusters 70 per cent (n=268) of the food stores were fixed, 20 per cent (n=78) were mobile stores and 9 per cent (n=36) were fixed mobile stores. All the mobile stores could not be captured due to the difference in the timings and location of visit to the village by the researcher. The third cluster had significantly had higher number of stores as compared to other two clusters (Figure 4.19).

Table 4.37: Distribution of different type of food stores

Type of store	Cluster 1 (n=65)	Cluster 2 (n=96)	Cluster 3 (n=221)	Total (n=382)	p-value*
Fixed store	43 (66.2)	69 (71.9)	156 (70.6)	268 (70.2)	0.45
Fixed mobile store	5 (7.7)	12 (12.5)	19 (8.6)	36 (9.4)	
Mobile store	17 (26.2)	15 (16.6)	46 (20.8)	78 (20.4)	

*p-value on the basis of chi-square test. Figures in parenthesis denote percentages.

The community food environment was expressed in terms of the store health index, the average hours of food accessibility in the neighborhood environment and the retail density of the stores. The store health index is expressed as the ratio of the healthy food categories available in the store to the number of unhealthy food categories available in a store. The food environment expressed in terms of Store Health Index was similar across three rural clusters with median index score of 1.0 but with significant difference across three rural clusters. This showed that there is an equal probability of the availability of a healthy and an unhealthy food category in the store. However, in the second cluster the food access to the households was for the longer durations (12.3 hours) as compared to the first (10.2 hours) and the third (11.4 hours) clusters respectively (Table 4.38). The store health index of the mobile store was found to be 0 as compared to 1.3 in a fixed store. This showed that the probability of finding a healthy food item in a mobile store was negligible, as compared to the 30 per cent more healthy food articles available in fixed stores (Table 4.39).

Figure 4.19: Fixed and mobile store in the village

Table 4.38: Community food environment characteristics around the households of children (6-12 years) (Median, IQR and 95% CI)

Indicators	Cluster 1 (n=65)		Cluster 2 (n=96)		Cluster 3 (n=221)		Total (n=382)		p-value*
	Median (P25, P75)	**95% CI**	**Median (P25, P75)**	**95% CI**	**Median (P25, P75)**	**95% CI**	**Median (P25, P75)**	**95% CI**	
Store health index^	1 (1.0, 1.2)[da]	1.0-1.0	1.2 (0.6, 1.4)[d]	1.0-1.0	1 (0.8, 1.1)[a]	1.0-1.1	1 (0.8, 1.1)	1.0-1.0	0.0001
Average number of hours food store opens	10.2 (8.7, 12.4)[d]	10.2-10.2	12.3 (12.1, 16.1)[de]	12.3-12.3	11.4 (11.2, 11.4)[e]	11.2-11.4	11.4 (10.3, 12.3)	11.4-11.4	0.0001
Total retail density#	10.7 (4.7, 14.4)[a]	10.7-10.7	12.1 (6.7, 13.7)[b]	12.1-12.1	9.2 (9.2, 13.3)[ab]	9.2-9.2	10.7 (7.3, 13.3)	10.7-10.7	0.006

^Store index is defined as ratio of number of healthy foods available in the shops to the number of unhealthy foods available in the shops
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0001$) as tested by Dunn's test
Retail density is calculated as number of stores in the village per 1000 population

Table 4.39: Store health index according to the type of food store (Median, IQR and 95% CI)^

Type of store	Median (P25, P75)	95% CI	p-value
Fixed store	1.3 (0.3, 1.8)[a]	1.2-1.4	0.0001
Fixed mobile store	0.3 (0.2, 1.3)[b]	0.2-0.4	
Mobile store	0 (0, 10)[ab]	0-0	

^Store health index is defined as ratio of number of healthy foods available in the shops to the number of unhealthy foods available in the shops
*p-value estimated using Kruskal Wallis test and Dunn's test for post-hoc estimations. Same superscripts (a/b) represents the significant differences ($p<0.05$) and (d/e) represents the significant differences ($p<0.0001$) as tested by Dunn's test

The Retail density of the stores is expressed as number of stores per 1000 population in a village. The expressed retail density of the cluster is the aggregation of the respective villages chosen in each cluster. The third cluster has significantly lower retail density (9.2) as compared to the first (10.7) and second (12.1) cluster. The second cluster being on the highway was found to be highly dense in terms of the population and number of retail units.

The distinct environmental exposures like availability of food items in the household, purchase behavior of the household, community food environment and socio-demographic characteristics of the three rural clusters represent distinct lifestyle behaviors of the recruited children (6-12 years). The community food environment around the households of the sampled children (6-12 year old) assessed only the availability of different food categories. The assessment of the variety and pricing of various food categories was not conducted.

4.2.8. School Environment of the Children (6-12 years)

The school environment of the sampled children (6-12 years old) comprised of the physical activity environment of the school and the eating environment of the school. The school environment assessment was significantly different across three rural clusters for both physical activity and healthy eating indicators (Table 4.40-4.41). The distribution of the sampled children (6-12 year old) according to the school of their study is described in Figure 4.20.

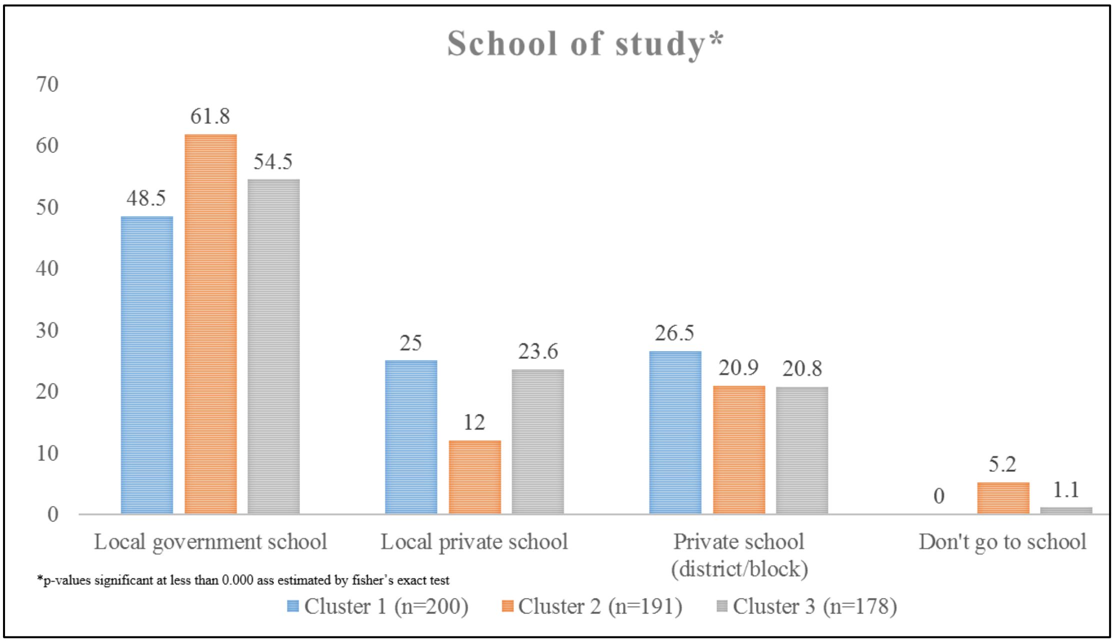


Figure 4.20: Distribution of children (6-12 year old) according to their school of study

The limitation of the school environment assessment included the assessment of only two schools (one government school and one private school) from each of the three sampled rural clusters. The data was projected according to the type of school (government or private) located in the respective cluster. However, a large proportion of the sampled children were found to be studying in the private schools or government school or *madarsas* located at the block or district level or in any other village. Thus, the data for the school environment was considered as missing data. The large proportion of children studying in the government school and village level private schools could be a reflection of the socio-economic conditions of the households. However, as per the national standards, the proportion of children studying in private schools has increased in rural areas (18.7% in 2006 to 29% in 2013) (ASER 2014).

Table 4.40: Distribution of children (6-12 year old) according to the school level physical activity environment

School environment indicators	Cluster 1 (n=147)	Cluster 2 (n=141)	Cluster 3 (n=138)	p value*
Presence of physical activity instructor in school	147 (73.5)	118 (61.5)	139 (78.1)	0.001
Availability of facilities for physical activity	50 (33.8)	141 (100.0)	138 (100.0)	0.000
Availability of equipment for physical activity	50 (34.0)	118 (83.7)	138 (100.0)	0.000
Promotion of physical activity in school$	50 (34.1)	0 (0.0)	138 (100.0)	0.000
Some time for physical activity in school	147 (100.0)	118 (83.7)	138 (100.0)	0.000
Participation of parents in encouraging physical activity at school@@	0 (0.0)	0 (0.0)	96 (69.6)	0.000

*p-value on the basis of chi-square test
$Physical activity in school is promoted through education/reward/special events/training and professional development of school staff/community partnerships
@@Parents are involved by taking suggestions regarding physical activity/their participation in school physical activity/involvement in planning and organizing events, or facilities related to physical activity
Figures in parenthesis denote percentages

Table 4.41: Distribution of children (6-12 year old) according to the school level eating environment

School environment indicators	Cluster 1 (n=147)	Cluster 2 (n=141)	Cluster 3 (n=138)	p value*
Availability of facilities for eating in school	147 (100.0)	0 (0.0)	0 (0.0)	0.000
Presence of canteen/convenience store/vending machine in school	50 (34.1)	0 (0.0)	0 (0.0)	0.000
Availability of Mid-day meal to students	97 (66.0)	118 (83.7)	96 (69.6)	0.001
Promotion of healthy eating in school@@	50 (34.1)	141 (100.0)	138 (100.0)	0.000
Parents involvement in promoting healthy eating in school@	0 (0.0)	0 (0.0)	42 (30.4)	0.000

*p-value on the basis of fisher's exact test
@@Promotion of healthy eating is done though sale or availability of healthy food in canteen/education in class and field trips/communication of healthy eating policies in school/training of teacher/community partnerships
@Parents are involved by taking their suggestions/discussions regarding healthy eating
Figures in parenthesis denote percentages

4.2.8.1. School Environment for Physical Activity

The indicators for assessing the environment for the physical activity in the schools where the sampled children (6-12 year old) were studying included the availability of facilities/equipment and promotional strategies used to increase the levels of physical activity in schools. The physical activity environment of the school was found to be significantly different ($p<0.05$) among the three rural clusters. The third cluster had better facilities, equipment, physical activity instructors and enhanced strategies for physical activity promotion in schools (Table 4.40). This active school environment could be related to the high levels of physical activity among the children (6-12 year old) in the third cluster. According to national standards, 37.3 per cent of the primary and 48.6 per cent of the upper primary schools have facilities for physical education (AISES, 2015).

Figure 4.21: School eating environment in the government school in study site

4.2.8.2. School Environment for Healthy Eating

The healthy eating environment of the schools across three rural clusters was significantly different (Table 4.41). The children studying in the schools located in the first cluster had access to canteen/convenience store (34.1%) and facilities for eating in school as compared to no canteen and facilities in the second and third cluster. However, the schools located in the third cluster promoted healthy eating through different promotional strategies like nutrition education, sending education material at home, including parents by taking their suggestions for improving eating environment in schools. These differences could also be due to the fact children in second and third cluster studied in the school located in their village and not at the block/district level. This reflects the differences in the socio-economic status of the households.

"यहां पर industralization बढ़ा है और सबके पास थोड़ा पैसा भी बढ़ा है"

(School teacher, Private school, Cluster 2)

The school built environment in terms of the facilities for eating and physical activity act as inhibitory and facilitating indicators for the health behavior of children (Story et al, 2009). The availability and opportunity for consuming foods and beverages high in sugar or fat in schools is associated with higher BMI among children (Kubik et al, 2005). The school level nutrition environment was significantly associated with children's BMI-for-age z scores (Wijnhoven et al, 2014).

4.3. Determinants of BMI of Rural Children (6-12 year old)

Significant differences were seen in various parameters at the individual, household (proximal) and community (distal) levels among children living in three rural clusters of Palwal district, Haryana. Hence, the determinants of BMI among the children (6-12 year old) studied will be discussed across these hierarchical levels. Since the prevalence of overweight and obesity in the present study was only 3 per cent, the outcome variable was dichotomized in to two categories "Thinness/Severe Thinness" and "Normal/Overweight/Obesity" for the determinant analysis at various hierarchies. These include:

– ***Individual level:*** food and nutrient intake, physical activity profile, sleep behavior, sensitivity to reward and restraint phenotype.
– ***Household level (Proximal determinants):*** Socio-demographic profile, socio-economic profile, household facilities and amenities, household level food availability and purchase behavior.

- ***Community level (Distal determinants):***cluster of residence, neighborhood built environment (density and landuse, safety, pedestrian infrastructure, roads, proximity to services, aesthetics and character), community food environment (retail density, average hours of food availability, store health index), school level eating environment (facilities for eating, presence of canteen, promotional activities) and physical activity environment (presence of physical activity facilities/equipments, physical activity instructors, promotion of physical activity).

4.3.1. Individual Level

4.3.1.1. Age and Gender

There were significant differences in the nutritional status of younger children among different age groups. Table 4.42 shows that younger children (6-10 years of age) were healthier as compared to the post-pubertal age group. In the 10-14 years age group, there was a significantly higher prevalence of thinness/severe thinness (59.4%) as compared to the younger age group (40.6%). While all age groups reported energy intakes more than the RDA, the differences between the two narrowed with increasing age. Hence, it may be possible that the actual energy requirements of the older children was much higher than the RDA and of the older children was not being met by their food intake.

Table 4.42: Distribution of children (6-12 years) according to their age and gender in different BMI categories

Determinants	**Severe thinness & thinness (n=128)**	**Normal & Overweight/Obese (n=442)**	**p value***
Age group (years)			
6≤10 years (n=293)	52 (17.8)	241 (82.3)	**0.006**
>10 to 14 years (n=277)	76 (27.4)	201 (72.6)	
Gender			
Male (n=279)	60 (21.5)	219 (78.5)	0.59
Female (n=291)	68 (23.4)	223 (76.6)	

*p-value on the basis of chi-square test
Figures in parenthesis denote percentages

However, there were no significant differences in the status of thinness/severe thinness across gender (Table 4.42). Children below 10 years are usually continued to be looked after closely by their parents while adolescents may like to behave more independent (Gandhi et al, 2014**). S**tudies have also shown the elder children (10-14 years) have higher odds of getting underweight with no significant difference across gender (Degarege et al, 2015; Herrador et al, 2014). This could be due to the differences in the feeding practices, parental care and morbidity profile of the two age groups (Gandhi et al, 2014; Katona and Katona-Apte, 2008).

4.3.1.2. Food Group Intake

It was interesting to note that there were no significant differences in the intake of different food groups among thin/severe thin and normal/overweight children (6-12 years old) except fat intake (Table 4.43).

Table 4.43: Food group intake among children (6-12 years) according to the BMI categories (Median, IQR and 95% CI)[@]

Food group	Severe thinness & thinness (n=67)		Normal & Overweight/Obese (n=226)		Total (n=293)		p value*
	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Cereals (g)	248.4 (195.6, 327.6)	228.2-280.6	247.3 (199.0, 314.0)	239.0-262.7	248.4 (200.0, 319.8)	241.5-261.0	0.66
Pulses (g)	21.5 (11.7, 42.0)	16.4-28.9	19.3 (12.5, 34.0)	17.8-22.9	19.4 (12.2, 36.5)	18.2-22.7	0.93
Milk and milk products (g)	287.6 (155.1, 487.8)	226.0-384.8	364.0 (204.2, 532.1)	327.7-404.2	338.3 (198.5, 519.5)	313.1-381.2	0.16
Vegetable (g)	123.5 (90.5, 180.6)	104.4-149.2	151.8 (81.9, 211.0)	134.7168.1	144.7 (86.9, 207.3)	131.0-157.8	0.7
Fruits (g)	34.8 (11.6, 92.4)	23.2-64.7	49.1 (22.4, 99.8)	39.6-61.6	43.2 (18.9, 94.5)	37.8-57.8	0.08
Fats and oils (g)	22.5 (13.2, 36.6)	18.6-26.9	29.4 (18.9, 42.7)	26.8-32.7	27.3 (17.6, 41.8)	27.9-30.6	**0.01**
Sugars and its products (g)	49.6 (32.1, 82.0)	39.7-65.0	57.9 (39.1, 87.4)	52.7-63.8	57.2 (37.5, 85.3)	51.4-62.7	0.41

*p-value on the basis of Wilcoxon rank sum test
@These food groups have been derived from 3-day 24 hour dietary recall

The fat was expressed as the visible fat in the daily dietary intake. The source of dietary visible fat in the rural area was found to be home produced *desi ghee* and butter from the buffalo whole milk. The fat intake among thin/severe thin children was 22.5g/d as compared to 27.3g/d among normal/overweight children. There has been an ambiguity in the literature regarding the role of dietary intake on the overall nutritional status of children. Shariff et al (2016) has shown that diet with high energy density i.e., higher fat is associated with under-nutrition among children. In the present study the sample was drawn from an agrarian economy, and there was a variety of staple food availability in the household for consumption. The dietary pattern analysis using principal component technique has shown no relationships between the fruit and vegetable based dietary pattern and BMI among children (Newby 2009). In addition, the role of fruit and vegetable role in preventing weight gain or on overall weight status of the child is indecisive.

4.3.1.3. Intake of Unhealthy Foods

The intake of unhealthy foods was derived from semi-quantitative food frequency questionnaire. There were no significant differences in the intake of unhealthy foods among children in different BMI categories except minor differences in the consumption of sweets and confectionaries (Table 4.44). It was important to note that almost 20 per cent of the total calories in the study subjects were derived from so called unhealthy food items. There were no significant differences in the frequency of consumption of various unhealthy foods between both the groups of children. The total frequency of consumption of unhealthy food items was 3.5 times per day out of which salty and fried snacks were consumed most frequently. The major sources of salty and fried snacks include chips, burger, *samosa* and locally produced refined flour based puffs *"pola"*. Pola is easily affordable and locally available on almost every retail outlet in the neighborhood. This increases the accessibility of the food item for consumption.

Table 4.44: Amount and frequency of consumption of unhealthy food and its total caloric contribution to the dietary energy (kcal) among children (6-12 years) according to the BMI categories (Median, IQR and 95% CI)[@]

Food group	Severe thinness & thinness (n=67)		Normal & Overweight/Obese (n=226)		Total (n=293)		p value*
	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Intake of unhealthy foods (grams)							
Unhealthy foods	166.8 (89.0, 314.7)	140.2-215.6	171.2 (107.0, 291.2)	158.1-183.4	171.1 (100.3, 297.5)	158.2-183.0	0.96
Sugar dishes (g)**	33.7 (7.9, 107.4)	23.3-48.1	26.6 (7.1, 64.1)	23.7-31.1	27.6 (7.5, 71.2)	25.0-32.2	0.06
Sweets (g)	33.9 (18.1, 68.4)	27.0-41.6	41.6 (25.0, 68.5)	38.3-46.0	39.7 (23.2, 68.5)	37.1-43.5	**0.05**
Salty and fried snacks (g)	49.9 (28.4, 82.3)	38.7-63.6	59.3 (29.3, 103.2)	51.6-64.9	56.5 (29.2, 93.1)	50.7-61.9	0.08
Sugar sweetened beverages (g)	5.2 (1.0, 68.6)	1.6-19.9	2.2 (1.0, 34.3)	1.6-3.0	2.6 (1.0, 38.2)	1.6-3.7	0.13
Bakery food products (g)	31.0 (11.6, 56.4)	18.9-42.1	32.3 (12.1, 60.7)	25.9-37.7	32.1 (12.1, 60.7)	26.4-35.7	0.85
Frequency of consumption of unhealthy foods							
Unhealthy foods $	3.3 (2.0, 4.9)	2.7-4.1	3.6 (2.2, 4.8)	3.3-3.8	3.5 (2.2, 4.8)	3.3-5.7	0.87
Sweets and confectionaries	0.7 (0.4, 1.3)	0.6-0.9	0.8 (0.4, 1.3)	0.8-0.9	0.8 (0.4, 1.3)	0.8-0.9	0.27
Salty and fried snacks	1.2 (0.6, 1.7)	1.0-1.3	1.2 (0.6, 1.9)	1.1-1.3	1.2 (0.6, 1.8)	1.1-1.3	0.82
Sugar sweetened beverages	0.02 (0.0, 0.3)	0.0-0.1	0.0 (0.0, 0.1)	0.0-0.01	0.01 (0.0, 0.1)	0.00-0.01	0.07
Bakery food products	0.6 (0.3, 1.3)	0.6-0.9	0.7 (0.3, 1.1)	0.6-0.9	0.7 (0.3, 1.1)	0.6-0.9	0.82
Caloric contribution of unhealthy foods to the dietary intake							
Unhealthy foods (kcal)$	648 (301, 1010)	486-739	664 (407, 1017)	611-719	660 (398, 1017)	611-714	0.21
Unhealthy foods-calorie %	22.2 (13.6, 28.7)	18.9-25.5	21.2 (14.2, 29.0)	19.4-22.4	21.3 (14.0, 28.8)	20.0-22.5	0.91

*p-value on the basis of Wilcoxon rank sum test
@These food groups have been derived from semi-quantitative food frequency questionnaire
$Unhealthy foods are defined as food items high in salt, sugar and fat. It includes sweets/salty and fried snacks/beverage/bakery
**Sugar based dishes includes some food items from sweets and confectionaries/ sugar sweetened beverages which contain only sugar as the major ingredient of preparation

As observed, in the rural community local barter system was still used for the purchase of food items. This practice was utilized by children to buy unhealthy food item from the local retail shops in exchange of the wheat (available at home) or any scrap, which was not in use by the household.

The median intake of sweets and confectionaries among thin/severe thin and normal/overweight children was 33.9g/d and 41.6g/d respectively. However, the median per day intake of sugar-based dishes was marginally more though not significantly high among severe thin/thin children (33.7g/d) as compared to normal/overweight children (26.6g/d). Sweets, white sugar and sugar-sweetened beverages contributed to the total sugar intake among children residing in rural areas (Maunder et al, 2015).The increase in proportion of sugars to the total energy decreased the contribution of other food groups to the diet among 4-8 year old children in South Africa.

The frequency of eating foods has been associated with the parental modeling behavior for children especially among rural areas. Blaine et al (2015) reported that among 2-12 year old children residing in low-income communities of Massachusetts, the frequency of offering snacks to children by parents is higher among normal weight children as compared to overweight children. The higher frequency of offering snacks to children was more for the non-nutritive reasons.

4.3.1.4. Energy (kcal) and Macronutrient Intake (g)

Dietary energy and macronutrient intake is an important determinant of BMI among children. There were no significant differences between the total calories intake between two categories of children, Although there was a trend of marginally lower energy intake among thin children (1933 kcal) as compared to normal/overweight children (2171.6 kcal) (Table 4.45 & 4.46). Thin children were consuming significantly more carbohydrates while normal children were having significantly higher amount of fat. Similar results have been reported among 6-9 year old girls and boys residing in Spain regarding the dietary energy intake and nutritional status of the children. The energy intake (kcal/d) among boys (6-9 year old) with underweight and normal weight was 1959±398 kcal/d and 2177±404 kcal/d respectively. Similar intakes were reported for undernourished and well nourished girls (6-9 years) (Morales-Suárez-Varela et al, 2015).

Table 4.45: Energy and macronutrient intake of the children (6-12 years) in different BMI categories (Median, IQR and 95% CI) @

Energy/Nutrient	Severe thinness & thinness (n=67)		Normal & Overweight/Obese (n=226)		Total (n=293)		p value*
	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Energy (kcal)	1933 (1667, 2463)	1840-2146	2172 (1826, 2641)	2092-2330	2138 (1779, 2558)	2056-2252	0.07
Carbohydrates (g)	306.9 (250.6, 359.6)	283.3-324.4	310.7 (253.4, 381.0)	299.5-327.7	309.5 (250.6, 379.5)	299.6-322.1	0.61
Protein (g)	52.6 (41.3, 59.4)	46.7-54.9	52.3 (42.8, 66.7)	49.9-57.0	51.9 (42.3, 64.7)	50.1-55.6	0.16
Fat (g)	56.1 (38.9, 72.2)	45.0-63.9	72.0 (51.3, 92.5)	66.1-75.1	66.5 (49.2, 89.0)	62.5-71.9	0.001

*p-value on the basis of Wilcoxon rank sum test
@These food groups have been derived from 3-day 24 hour dietary recall

Table 4.46: Percentage energy from macronutrients of the children (6-12 years) in different BMI categories (Median, IQR and 95% CI) @

Macronutrient	Severe thinness & thinness (n=67)		Normal & Overweight/Obese (n=226)		Total (n=293)		p value*
	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Carbohydrates en%	62.2 (55.6, 68.6)	57.5-64.7	58.0 (51.9, 63.7)	56.5-59.4	58.5 (53.0, 65.0)	57.4-60.2	**0.007**
Protein en%	10.1 (9.2, 11.2)	9.6-10.5	9.6 (9.1, 10.7)	9.6-9.9	9.7 (9.1, 10.8)	9.6-10.0	0.29
Fat en%	24.8 (19.7, 30.8)	21.8-28.9	29.0 (24.4, 34.3)	28.1-30.3	28.6 (22.7, 33.4)	27.4-29.3	**0.002**

*p-value on the basis of Wilcoxon rank sum test
@These food groups have been derived from 3-day 24 hour dietary recall

There were significant differences in the proportion energy per cent derived from carbohydrates and fat (Table 4.46). The carbohydrates form the major staple in the diet of local population and contributed to 62.2 per cent energy among thin/severe thin children as compared to 58.5 per cent among normal children. The major sources of carbohydrates in the diet of children include wheat and its products, bakery products, mid-day meal and sugar and its products. There was no significant difference in the contribution of protein to the total energy among children (6-12 year old) in different BMI categories. The fat contribution to the total dietary energy was significantly higher in the normal/overweight group.

4.3.1.5. Physical Activity Profile and Sleep Behavior

Physical activity is the major determinant of BMI influencing the energy balance equation among children. We determined two measures of physical activity: met minutes estimation for the physical activity and physical activity level (PAL). There were no significant differences in the total met minutes of physical activity done by the children (6-12 year old) in different BMI categories (Table 4.47). However, the met minutes of physical activity was significantly different for TV watching among children in different BMI categories (Table 4.47). There were minor differences in the sleep behavior of two groups of children: thin children were sleeping 15 minutes more than normal/overweight children.

Table 4.47: Total met minutes and sleep duration (minutes) among children (6-12 years) in different BMI categories (Median, IQR and 95% CI) @

Parameter	Severe thinness & thinness (n=127)		Normal & Overweight/Obese (n=440)		Total (n=567)		p value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Total met minutes	2528.4 (2131.8, 3012.9)	2364.4-2701.5	2538.2 (2203.8, 3019.5)	2438.1-2620.8	2532.1 (2192.4, 3019.2)	2438.1-2603.9	0.71
Games and sports	623.3 (309, 1020)	460.7-735.3	609.4 (310.8, 1080.5)	553.4-670.5	615.8 (310.1, 1053.1)	558-666.6	0.65
School travel	46.5 (0, 75.6)	31.5-63	31.5 (0, 63)	30.8-41.0	31.5 (0, 63)	31.5-42	0.09
School based activities	22.5 (0, 101.3)	0-44.3	7.9 (0, 75.7)	0-21.0	10 (0, 78.8)	0-22.5	0.24
Leisure time activities	266.6 (124, 420.0)	209.2-332.7	245.4 (133.5, 394.6)	224.0-268.3	251 (130.4, 401.3)	229.8-270.4	0.68
Household chores	3.6 (0, 54)	0-18	0 (0, 49.3)	0-1.1	0 (0, 51.3)	0-2.3	0.17
Television watching	90 (45, 157.5)	90-112.5	90 (0, 135)	78.6-90	90 (27, 157.5)	90-90	**0.03**
Residual time	878.1 (745.9, 946.4)	848.8-902.8	881.1 (768.7, 967.4)	862.9-896.8	879.1 (765.6, 962.2)	864.9-893.7	0.3
Sleep behavior							
Total sleep duration (minutes)$	540 (486, 594)	540-540	540 (486, 594)	540-540	540 (486, 594)	540-540	0.4

*p-value on the basis of Wilcoxon rank sum test
@Sleep duration has been taken from physical activity-b questionnaire

Table 4.48: Distribution of children (6-12 years) according to the mode of transportation for commuting (home to school) in different BMI categories

Mode of transport	Severe thinness & thinness	Normal & Overweight/Obese	Total	p value*
Active mode^ (n=381)	97 (80.2)	284 (66.4)	381 (69.4)	**0.004**
Passive mode@ (n=168)	24 (19.8)	144 (33.6)	168 (30.6)	

*p-value on the basis of chi-square test
^Active mode includes walking and cycling
@Passive mode includes motorized transport (car/bike/scooter/bus)
Figures in parenthesis denote percentages

There were however, significant differences in the mode of transport used by children (6-12 year old) for travelling to school. More than three-fourth of the thin/severe thin children (80.2%) preferred active mode of transportation as compared to 66.4 per cent normal/overweight children. Active mode of transportation included walking and cycling; and passive mode of transportation included the use of motorized transport (car/bike/scooter/bus) for commuting (Table 4.48). It has been shown that the children (9-11 years) who were engaged in active school transportation had a higher level of total MVPA (Moderate-to-Vigorous Physical Activity) (Denstel et al, 2015). Fisher et al (2011) in a longitudinal cohort of children (n=280; 8-10 year old) showed that higher duration of time spent in total MVPA throughout the day was significantly associated with the lower levels of adiposity among children (adjusted for BMI, sex, socio-economic status and ethnicity). This could have an indirect support to the finding of the present research study. Similar findings were reported by Gunter et al (2015) regarding the relationship between physical activity and BMI among children (6-12 year old) residing in rural areas of Oregon. The study showed that there was difference in the total duration of MVPA (min/d) in which the normal (19 min/d) and overweight (15 min/d) children were engaged.

Table 4.49: Distribution of children (6-12 years) according to the Physical Activity levels (PAL) in different BMI categories@

PAL category	Severe thinness & thinness	Normal & Overweight/Obese	Total	p value*
Sedentary active (n=262)	61 (48.0)	201 (45.7)	262 (46.2)	0.79
Moderately active (n=124)	25 (19.7)	99 (22.5)	24 (21.9)	
Vigorously active (n=181)	41 (32.3)	140 (31.8)	181 (31.9)	

@PAL is categorized using cut-offs given FAO/WHO/UNU (2004)
*p-value on the basis of chi-square test
Figures in parenthesis denote percentages

The physical activity levels (PAL) was also not significantly different among children according to their BMI (Table 4.49). Therefore, in the present research study the association between physical activity profile and BMI of the children was insignificant. This could be due to the fact that in the rural areas all the children regardless of their weight status participated in moderate and vigorous physical activities.

4.3.1.6. Eating Pattern Phenotypes

Behavioral Inhibition scale/Behavioral activation scale (BIS/BAS) explains the sensitivity to reward phenotype among children and restraint phenotype is explained by eating behaviors (restraint, external and emotional). In the present research study, the BAS scores of the thin/severe thin children (6-12 year old) was significantly higher ($p<0.05$). There was no significant difference the external and emotional behavior of the thin or normal children (6-12 year old) (Table 4.50).

Table 4.50: Total scores of sensitivity to reward and restraint phenotype indicators among children (6-12 years) in different BMI categories (Median, IQR and 95% CI)

Indicator	Severe thinness & thinness (n=128)		Normal & Overweight/Obese (n=442)		Total (n=570)		p value*
	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	Median (P25, P75)	95%CI	
Behavioral Inhibition score	23 (19, 27)	22-24	24 (20, 27)	23-24	23.5 (20, 27)	23-24	0.84
Score of total behavioral activation score (BAS Score)$	51 (44, 55)	49-52	49 (41, 53)	48-50	49 (41, 54)	48.1-50	**0.01**
External eating$	46.5 (41.5, 52.9)	44.4-48.9	45.7 (41.3, 51.9)	45.2-46.8	46.0 (41.5, 52.1)	45.2-46.8	0.59
Emotional eating$	30.6 (27.1, 35)	29.5-32.3	31.0 (27.7, 35.1)	30.0-31.4	30.8 (27.3, 35.1)	30-31.1	0.8

*p-value on the basis of Wilcoxon rank sum test
$Total BAS score includes the scores of all sub-components: fun-seeking, reward responsiveness and drive
$Eating behavior scores are expressed as percentage of the total score.

This contradicted the findings of Jansen et al (2008), where it was shown that the children having higher BAS scores had higher weights. This was due the impaired neural control which resulted in higher food intake. However, food environment surrounding the individual also plays an important role in the appetitive stimuli of children, as reiterated by Guerrieri et al (2008) who showed that the children who do not have weight problems are also more sensitive to the diverse food environment surrounding them. The thin children in the present study were more likely from poor households and likely to experience different food environment but factors for their BMI cannot be explained.

4.3.2. Household Level (Proximal determinants)

4.3.2.1. Household Characteristics

The socio-demographic characteristics and sanitation/hygiene indicators play an important role in the nutritional status of the child (Chirande et al, 2015; Kavosi et al, 2014).

Table 4.51: Distribution of children (6-12 years) according to the socio-demographic, socio-economic indicators in different BMI categories

Determinants	Severe thinness & thinness (n=128)	Normal & Overweight/Obese (n=442)	p value*
Maternal education			
Illiterate and primary education up to 5 years of schooling	101 (78.9)	308 (69.7)	0.05
More than 5 years of schooling$	27 (21.1)	132 (29.9)	
Toilet use			
In toilet	69 (53.9)	281 (63.6)	0.05
In open field	59 (46.1)	161 (36.4)	
Socio-economic status^			
Rich class	19 (14.8)	102 (23.1)	0.021
Upper middle class	27 (21.1)	131 (29.6)	
Middle class	29 (22.7)	80 (18.1)	
Lower middle class	32 (25.0)	80 (18.1)	
Poor class	21 (16.4)	49 (11.1)	
Paternal education			
Illiterate and primary education up to 5 years of schooling	34 (26.6)	104 (23.7)	0.50
More than 5 years of schooling$	94 (73.4)	335 (76.3)	
Paternal Occupation			
Unemployed or agriculture based activities	76 (59.4)	233 (53.1)	0.20
Business and service class	52 (40.6)	206 (46.9)	
Number of sleeping in same room			
1-2 members	110 (24.9)	32 (25.0)	0.94
3-5 members	298 (67.4)	85 (66.4)	
More than 5 members	34 (7.7)	11 (8.6)	

$It includes high school/senior secondary schooling/graduate/post graduate and higher education categories.
*p-value on the basis of chi-square test.
^ Socio-economic status is calculated by giving weighted scores to 19 indicators and dividing in quintiles.
Figures in parenthesis denote percentages

These include maternal and paternal education and occupation, socio-economic status of the household, monthly income of the households, toilet use, and source of drinking water. In the current study, the mothers of the thin children were more likely to be illiterate and these children were using open field for defecation more than their healthy counterparts; higher proportion of these were from poor and lower middle class households according to socio-economic class (Table 4.51). However, in the current sample there were no significant differences in the family size, paternal education/occupation, overcrowding of the households (number of members sleeping in the room). Although there was higher prevalence of thin/severe thin children in households where the source of drinking water was not clean, the differences were not significant.

The housing characteristics like kutcha house, urban/rural location, socio-demographic characteristics have a bearing on the nutritional status of the child (Alelign et al, 2015). The possession of the livestock in the household significantly reduces the risk of stunting among children (Mosites et al, 2015). The household demographic factors play a role in the governing the morbidity status of the child and thus the nutritional status (Lin et al, 2013). The authors reported that the children residing in households with clean environmental conditions in Bangladesh have lower magnitude of the environmental enteropathy indicators and higher z scores of Height-for-age. The source of drinking water also had impact on the child's growth (Kamal et al, 2015). The solid bio-mass used a cooking fuel has been also related with the higher prevalence of stunting and anemia among children in India (Mishra and Retherford, 2006). There were significant differences in the per capita income of the household according to the nutritional status of the child. Mean per capita income in the households of undernourished children was approximately 150 INR less than the households wherein the nutritional status of the children was normal/overweight. All these parameters are estimated during the calculation of socio-economic class of the household, thus, making socio-economic status a strong determinant of the nutritional status of the child residing in the household (Table 4.51).

These findings are supported by the previous literature that the socio-demographic characteristics have a bearing on the nutritional status of children (Alelign et al, 2015).

Socio-demographic status, sanitation and hygiene facilities, morbidity among children measured as repeated occurrence of infections, higher density in the household, maternal weight and height, maternal and paternal education and occupation, parity and seasonal disparity especially rainy season are all significant determinants of nutritional status among children (Chirande et al, 2015; Kavosi et al, 2014; Ramirez-Zea et al, 2014; Bygbjerg 2012; Meshram I et al, 2012; Martorell and Young 2012; Srivastava et al, 2012; Kanjilal et al, 2010; Wamami et al, 2007).

4.3.2.2. Household Food Availability

The home food environment characterized by the availability and accessibility of foods in the households has relationship with the nutritional status of the child (Vilchis-Gil et al, 2015; Spurrier et al, 2008; Rosenkranz et al, 2008). There was significantly higher per capita per month availability of the different food groups in the households of normal/overweight children vis-à-vis thin/severe thin children (Table 4.52). These food groups include pulses, milk and milk products, fats and oils and sweets and confectionaries. The availability of unhealthy food was however similar in two types of homes. The availability of healthy and unhealthy foods in the household was found to be positively correlated with the consumption of the same by the child (Vilchis-Gil et al, 2015; Spurrier et al, 2008). This is similar to the findings of the present study where there is a high intake of milk and milk products, sugars, fats and oils and unhealthy foods among children (6-12 year old). It has been shown that there is a greater availability of fresh fruits and vegetables in the household of non-obese children as compared to obese children (Boles et al, 2013). The availability of all the food groups is higher among the households of normal/overweight children as compared to the thin/severe thin children. These differences could be due to the differences in the socio-economic status of the households of the two groups of children. Although we did not detect any significant differences in the consumption of the food among the two groups (Table 4.43), higher availability of overall food in the households of well nourished children (Table 4.52) may indicate errors in the estimation of food consumption. Such errors have been found with various dietary estimation techniques; particularly when the differences are not huge between the groups (Day et al, 2004).

Table 4.52: Amount of per capita per month food availability of various food categories among the households of children (6-12 years) in different BMI categories (Median, IQR and 95% CI)

Food group	Severe thinness & thinness (n=61)		Normal & Overweight/Obese (n=220)		Total (n=281)		p value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Cereals (kg)	7.1 (4.5, 7.0)	5.8-7.9	8.2 (5.8, 11.3)	7.7-8.7	8.0 (5.7, 10.8)	7.5-8.4	**0.01**
Pulses (g)	321.9 (121.1, 501.8)	206.9-394.0	387.5 (200.9, 650)	334.9-421.5	366.7 (183.8, 603.7)	323.6-400	**0.03**
Milk and milk products (kg)	7.0 (2.5, 17.3)	4.2-11.8	12.9 (5.4, 23.0)	10.7-15.1	11.9 (4.6, 21.5)	9.8-13.4	**0.003**
Fruits and vegetables (g)	734.7 (375.0, 1207.7)	599.3-917.5	755.3 (316.1, 1412.5)	663.2-897.9	750 (327.4, 1375.5)	661.9-873.9	0.6
Fats and oils (g)	460.7 (271.6, 746.7)	384.1-555.9	521.1 (305.5, 841.5)	478.5-564.3	500 (293.3, 807.3)	461.7-546.1	**0.05**
Sugars and its products (g)	1839.3 (1257.2, 3133.3)	1398.5-2556.2	2126.3 (1266.1, 3159.1)	1957.1-2295.5	2100 (1261.9, 3143.8)	1920.6-2272.2	0.69
Total unhealthy food (g)$	750.7 (402.2, 1176.2)	564.6-929.9	831.4 (447.8, 1409.3)	668.3-973.0	769.4 (441.5, 1377.2)	664.3-922.3	0.18
Sweets and confectionaries (g)	94 (19.3, 277)	45.0-163.9	244 (80.2, 553.2)	193.0-290.4	208.9 (48.2, 517.6)	168.5-250	**0.01**
Salty and fried snacks (g)	103.9 (52.0, 196.7)	73.2-155.5	118.1 (42.5, 255.4)	96.0-137.0	116.7 (44.0, 240.9)	95.6-135.0	0.39
Bakery products (g)	152 (61.3, 364.9)	86.9-226.4	129.1 (55.7, 355.4)	112.4-165.5	135.7 (56.5, 360.1)	114.3-168.7	0.24
Beverages (g)	75 (28.2, 221.7)	49.0-118.1	82.7 (32.7, 208.8)	67.0-104.2	80 (32.1, 209.7)	68.4-95.6	0.72

*p-value on the basis of Wilcoxon rank sum test. $ Unhealthy food group include sweets and confectionaries, salty and fried snacks, bakery products and beverages. Figures in parenthesis denote percentages

4.3.2.3. Purchase Behavior

Purchase behavior at the household was explained as total food expenditure and percentage of total expenditure on healthy and unhealthy foods (Table 4.53 and Table 4.54). Total expenditure included the direct and indirect costs incurred in purchase and procurement of any food item in the household. The indirect costs for food procurement was imputed for the items sourced from farms/fields or self-produce, received as gift from neighbor/relatives household, government programs like ICDS/MDM or obtained in barter system. The purchase frequency was higher in the households of severe thin/thin children as compared to the households of normal/overweight group children. In the households of normal/overweight children, 1038.8 INR per capita was spent on the food expenditure from all sources as compared to 751.0 INR in the households of thin/severe thin children ($p<0.05$). Out of which in the households of normal children nearly 41 per cent was being procured from the market vis-à-vis 54 per cent in the households of thin children. Proportion spent on healthy and unhealthy foods was similar in two types of households. Direct expenditure i.e. out of pocket expenditure was similar in two categories of households (INR 407 in thin and INR 430 per capita in normal nourished households).

Table 4.53: Total food expenditure (INR) and % total food expenditure on various food categories among the households of sampled children (6-12 years) in different BMI categories (Median, IQR and 95% CI)[@]

Food group	Severe thinness & thinness (n=61)		Normal & Overweight/Obese (n=220)		Total (n=281)		p value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Per capita total food expenditure (INR)	751.0 (557.3, 1221.4)	691.2-939.8	1038.8 (683.5, 1409.1)	964.9-1127.7	992 (659.2, 1357.7)	900.1-1066.3	**0.007**
Total healthy food (%)	92.5 (86.5, 97.6)	89.3-95.4	92.5 (87.8, 97.0)	91.5-93.9	92.5 (87.7, 97.1)	91.5-94.0	0.67
Cereals	11.2 (5.9, 18.7)	8.8-12.3	10.1 (6.6, 16.0)	9.4-11.6	10.4 (6.6, 16.3)	9.6-11.4	0.79
Pulses and legumes	2.1 (0.8, 3.4)	1.4-2.7	1.8 (0.8, 3.3)	1.3-2.1	1.8 (0.8, 3.3)	1.4-2.1	0.59
Milk and milk products	40.4 (22.6, 58.8)	32.6-49.7	50.1 (28.5, 66.9)	45.0-55.7	48.3 (27.2, 66.1)	43.5-52.8	0.09
Meat, fish and poultry	8.4 (4.6, 10.8)	5.8-9.8	7.0 (3.1, 13.7)	5.9-9.7	7.3 (3.8, 13.6)	6.2-9.3	0.74
Fruits	3.4 (1.6, 6.3)	2.4-5.1	2.9 (1.5, 5.7)	2.3-3.5	3.0 (1.5, 5.8)	2.6-3.5	0.33
Vegetables	10.4 (5.5, 14.7)	8.5-12.4	8.6 (6.2, 12.9)	8.0-9.4	9.0 (6.1, 13.2)	8.3-9.7	0.28
Fats and oil	5.1 (1.6, 10.9)	2.6-6.6	3.8 (2.0, 8.5)	3.3-4.9	3.8 (2.0, 8.7)	3.3-5.2	0.79
Sugars	9.4 (5.8, 14.3)	7.9-12.1	6.7 (4.0, 10.1)	5.9-7.4	7.2 (4.1, 11.6)	6.5-8.1	**0.003**
Total unhealthy food[$]	11.1 (5.1, 14.4)	7.1-11.8	9.0 (5.3, 13.6)	8.1-10.2	9.2 (5.3, 13.7)	8.3-10.4	0.60
Sweets and confectionaries	1.9 (0.5, 3.9)	0.9-2.1	2.7 (1.1, 5.4)	2.1-3.3	2.3 (0.9, 5.2)	2.0-2.8	**0.04**
Salty and fried snacks	1.4 (0.9, 2.7)	1.1-1.8	1.5 (0.7, 2.6)	1.2-1.7	1.5 (0.7, 2.6)	1.2-1.6	0.71
Bakery products	1.4 (0.7, 4.1)	0.9-2.8	1.0 (0.4, 2.9)	0.8-1.4	1.1 (0.5, 3.1)	0.9 -1.4	0.04
Beverages	1.9 (1.3, 5.4)	1.6-3.0	2.2 (1.2, 4.1)	1.9-2.6	2.2 (1.2, 4.2)	1.9-2.5	0.99

@Total food expenditure includes the money spent in market and indirect costs spent in food procurement through farms/field, barter system and received as gifts by neighbors/relatives
*p-value on the basis of Wilcoxon rank sum test. $ Unhealthy food group include sweets and confectionaries, salty and fried snacks, bakery products and beverages. Figures in parenthesis denote percentages

Table 4.54: Market spent food expenditure on various food categories among the households of sampled children (6-12 years) in different BMI categories (Median, IQR and 95% CI)

Food group	Severe thinness & thinness (n=61)		Normal & Overweight/Obese (n=220)		Total (n=281)		p value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95%CI	
Total food expenditure in market (per capita)	407.5 (259.2, 503.0)	327.7-454.2	430.8 (282.7, 615.5)	384.1-480.2	421.2 (276.1, 586.4)	384.9-453.9	0.22
Total healthy food	83.5 (75.6, 88.9)	81.5-85.7	82.0 (74.8, 88.9)	80.1-83.9	82.6 (75.1, 88.9)	80.7-83.9	0.42
Cereals	2.2 (0.3, 4.6)	1.6-3.1	1.3 (0, 3.1)	1.0-1.7	1.6 (0, 4.0)	1.1-1.8	0.09
Pulses and legumes	3.7 (1.9, 5.6)	2.5-4.1	3.7 (2.0, 6.4)	3.1-4.2	3.7 (2.0, 6.0)	3.2-4.1	0.34
Milk and milk products	25.6 (11.8, 36.7)	17.9-31.5	23.2 (12.6, 34.4)	20.0-27.3	23.8 (12.6, 25.5)	21.0-27.3	0.70
Meat, fish and poultry	8.1 (3.2, 16.9)	4.2-13.6	9.6 (4.5, 18.0)	6.9-14.1	9.3 (4.0, 17.7)	6.9-13.2	0.51
Fruits	5.9 (2.8, 8.8)	4.0-7.4	5.5 (2.6, 10.1)	4.7-6.6	5.6 (2.7, 10.0)	4.8-6.4	0.88
Vegetables	17.0 (12.9, 24.1)	14.8-20.9	19.2 (13.5, 26.7)	17.4-21.2	19.0 (13.2, 25.8)	17.3-20.3	0.29
Fats and oil	9.4 (4.8, 15.7)	6.2-12.4	9.0 (4.9, 16.1)	7.7-10.2	9.0 (4.9, 16.0)	7.8-10.1	0.88
Sugars	18.2 (10.7, 25.8)	14.9-21.8	15.9 (9.4, 24.0)	13.9-18.5	17.4 (9.6, 25.4)	14.8-18.7	0.30
Total unhealthy food$	16.5 (11.1, 24.1)	14.3-18.4	18.1 (11.3, 25.2)	16.1-19.9	17.5 (11.3, 24.9)	16.2-19.3	0.39
Sweets and confectionaries	2.1 (0.7, 5.1)	1.3-3.3	3.8 (1.7, 8.6)	3.3-4.7	3.5 (1.3, 7.9)	2.9-4.1	**0.008**
Salty and fried snacks	3.0 (1.6, 5.7)	2.1-4.3	3.3 (1.8, 6.6)	2.8-3.9	3.2 (1.8, 6.4)	2.8-3.8	0.63
Bakery products	3.2 (1.4, 6.8)	1.7-4.9	2.7 (1.1, 5.5)	2.2-3.1	2.7 (1.2, 5.7)	2.3-3.1	0.19
Beverages	4.5 (2.3, 8.4)	3.3-6.9	4.9 (2.6, 9.6)	4.1-6.1	4.8 (2.5, 9.0)	4.1-5.9	0.49

*p-value on the basis of Wilcoxon rank sum test.
$ Unhealthy food group include sweets/ confectionaries, salty/fried snacks, bakery products and beverages.
Figures in parenthesis denote percentages

Evidently, these differences were due to the differences in the socio-economic class of the household and the poor resources of agriculture farming/subsistence farming in the households. Apart from the total expenditure there were also significant differences in the percentage expenditure on sugars and sweets/confectionaries among the households of two groups. The households of thin/severe thin children spent 9.4 per cent of their total household expenditure on sugars and its products as compared to 6.7 per cent of the normal/overweight children households. This could be the reason for the high sugar intake among their children (6-12 year old). It was interesting to note that 40-50 per cent of the expenditure of the healthy component was spent on purchase of milk indicating cultural preferences irrespective of the SES of the household. The percentage expenditure on milk and milk products was slightly higher among normal/overweight households (by 10 per cent) as compared to thin/severe thin households though the difference was not significant.

This reflects the poor resource environment of the households (thin/severe thin) with low domestic animals, considering the milk was one of the major food item in the household food inventory. While the total food expenditure was significantly higher ($p<0.05$) in normal/overweight group of children, there were no significant differences in the direct food expenditure of the households of children in two groups. It appeared that households with normal children had greater resources available within their families in the form of farms, cattle, social capital to name a few so that they were able to procure additional foods items worth almost 30 per cent of that in households with undernourished children. The households of normal/overweight children were spending significantly higher percentage on sweets and confectionaries. This could be due to the higher costs of sweets in the markets which might be unaffordable by the poor households. This was also related to the higher intake of sweets/confectionaries among normal/overweight children.

4.3.3. Community Level (Distal Determinants)

4.3.3.1. Neighborhood Built Environment

The built environment assessment in the present research study has been done across various domains. These domains include pedestrian infrastructure, density and land use, roads/streets/parking, safety and aesthetics/character. Table 4.55 represents no significant differences in the scores of few attributes of built environment neighboring the households of the children in two groups. The comprehensive built environment score and scores for different domains were also estimated and no significant differences emerged. This showed that the neighborhood built environment in the 500 meters of the household had no significant differences in the nutritional status of children. The built environment functions by influencing the physical activity behavior of child and thus nutritional status (Oliver et al, 2011; Gordon-Larsen et al, 2006). The nine villages included in the study had compact settlement pattern and within 20 per cent of total village area 86 per cent of total village buildings (structures) were concentrated (INCLEN study, 2016). The GIS data was generated using nearest neighborhood and structural patch analysis. This compact residential environment will probably therefore nullify its effect on the nutritional status of the study children.

Table 4.55: Distribution of different attributes of built environment surrounding the households of children (6-12 year old) according to the BMI categories

Built environment indicators	**Severe thinness & thinness (n=68)**	**Normal & Overweight/Obese (n=226)**	**Total (n=294)**	**p value***
Highly dense[@] *(Density and land use)*	45 (66.2)	130 (57.5)	175 (59.5)	0.2
Visual and auditory crossing signals *(Pedestrian infrastructure)*	39 (57.4)	106 (46.9)	145 (49.3)	0.13
No cracks/dirt/debris on the streets *(Roads, streets and parking)*	5 (7.4)	34 (15.0)	39 (13.3)	0.06
No traffic calming devices on the streets *(Roads, streets and parking)*	7 (10.3)	53 (23.5)	60 (20.4)	0.06
Neighborhood not safe from stray animals *(Safety)*	16 (23.5)	86 (38.1)	102 (34.7)	0.07
No lighting facility in the neighborhood *(Safety)*	45 (66.2)	122 (54.0)	167 (56.8)	0.07

*p-value on the basis of chi-square test
@Highly dense is closely constructed and/or multi storey buildings in the area with unused space
Figures in parenthesis denote percentages

4.3.3.2. Community Food Environment

The community and consumer food environment had influence on the children's diet (Engler-Stringer et al. 2014). We did not observe any significant difference in the community food environment of the two categories of children: retail density and time these stores were open (Table 4.56). The average duration for which food was available in the neighborhood environment was approximately half to three-fourth of an hour more near the homes of undernourished children compared to well-nourished subjects; this difference was not statistically significant. However, in terms of availability of overall food and unhealthy food at home (refer previous section), there were clear differences in the per-capita total food availability in the households (more in houses of well-nourished children) but unhealthy food was available in similar amounts in two types of households. The access to low healthy index stores to categories of children was significantly different from each other statistically. However the median index was same across both the categories but the differences in 95 per cent CI explains the differences in the level of significance (Table 4.56).

Table 4.56: Food retail environment indicators around the households of recruited children (6-12 years) in different BMI categories (Median, IQR and 95% CI)

Retail environment indicator	Severe thinness & thinness (n=54)		Normal & Overweight/Obese (n=184)		Total (n=246)		p value*
	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	Median (P25, P75)	95% CI	
Store Health Index	1.01 (0.8,1.1)	0.95-1.01	1.01 (0.8,1.1)	1.00-1.01	1.01 (0.8, 1.1)	1.00-1.01	**0.04**
Total retail density@	12.1 (9.2, 13.6)	10.7-12.1	10.7 (7.3, 13.7)	9.2-10.7	10.7 (7.3, 13.7)	10.7-10.7	0.4
Average number of hours food store opens	12.1 (10.3, 12.4)	11.4-12.2	11.4 (10.3, 12.3)	11.4-11.4	11.4 (10.3, 12.3)	11.4-11.4	0.06

*p-value on the basis of Wilcoxon rank sum test
@Retail density was calculated as number of retail shops present per 1000 population in a village

There is an ambiguity in the findings of the community food environment and the nutritional status of the child. This is due to the indirect influence of the foods available in the community and dietary intake and the nutritional status of the child (6-12 year old) (Boone-Heinonen et al, 2013; Caspi et al, 2012). Rundle et al (2014) from New York classified stores as BMI healthy or unhealthy stores. They found that the median density (stores/km^2) of unhealthy food stores was 64.19 around the homes of obese children while healthy stores density was 10.98/km^2; these observations were however not significantly associated with the BMI of the subjects in this study. There has also been a higher reported intake of snack foods like sweets, chocolates and crisps in the close proximal area of convenience stores but with a very small effect size of distance to and density of food outlets in the neighborhood (Skidmore et al, 2010).

4.3.3.3. School Eating and Physical Activity Environment

School contributes to a significant proportion of child's daily energy intake (19-50%) and had a profound impact on the lifestyle of the child (Kubik et al, 2005). There was a significant difference in the types of school in which the children were going and the nutritional status of the child (Table 4.57). More than half of the children recruited for the investigation were going to local government school (54.8%). However, the well-nourished children were more likely to go private schools in their own locality or at the block/district headquarters. This may reflect the SES differences in the two populations but school environment may also be contributing to the nutritional status of the children.

Table 4.57: Distribution of children (6-12 year old) according to the school of study in different BMI categories

School type category	Severe thinness & thinness (n=128)	Normal & Overweight/Obese (n=442)	Total (n=570)	p value*
Government school	85 (66.4)	227 (51.5)	312 (54.8)	0.01
Private school located in village	22 (17.2)	93 (21.1)	115 (20.2)	
Private school located in district/ block or *madarsa* outside village	17 (13.3)	113 (25.6)	130 (22.9)	
Children who don't go to school	4 (3.1)	8 (1.8)	12 (2.2)	

*p-value on the basis of chi-square test
Figures in parenthesis denote percentages

Table 4.58 describes the physical activity and healthy eating environment indicators of the schools according to nutritional status of children.

We had major limitation in terms of number of schools assessed for the study. Only one public/government and one private school per cluster were assessed for various parameters that facilitate physical activity. Therefore not much inference may be made from this data. There were no significant differences in the school environment of children according to their nutritional status, although the school environment was significantly different across three rural clusters. Poti et al (2014) showed that the relative contribution of empty calories to the total energy intake (kcal) is equal across various locations. These include stores, fast food restaurants and schools. In the present research study, a little over half of the children were studying in the government schools where they were served mid-day meals. This could contribute to non-significant influence of the eating and physical activity environment of schools on the subjects' nutritional status.

Table 4.58: Distribution of children (6-12 year old) according to the school level environment in different BMI categories

School physical environment indicators	Severe thinness & thinness (n=107)	Normal & Overweight/Obese (n=319)	Total (n=426)	p value*
Physical activity indicators				
Presence of physical activity instructor in school	101 (78.9)	303 (68.6)	404 (70.9)	**0.023**
Availability of facilities for physical activity	84 (78.5)	245 (76.8)	329 (77.2)	0.716
Availability of equipment for physical activity	78 (72.9)	228 (71.5)	306 (71.8)	0.375
Promotion of physical activity in school$	39 (36.5)	149 (46.7)	188 (44.1)	0.06
Participation of parents in encouraging physical activity at school@@	23 (21.5)	73 (22.9)	96 (22.5)	0.766
Healthy eating indicators				
Availability of facilities for eating in school	32 (29.9)	115 (36.1)	147 (34.5)	0.247
Presence of canteen/convenience store/vending machine in school	9 (8.4)	41 (12.9)	50 (11.7)	0.217
Availability of Mid-day meal to students	85 (79.4)	226 (70.9)	311 (73.0)	0.08
Promotion of healthy eating in school**	84 (78.5)	245 (76.8)	329 (77.2)	0.716
Parents involvement in promoting healthy eating in school^	7 (6.5)	35 (11.0)	42 (9.9)	0.18

*p-value on the basis of chi-square test
$Physical activity in school is promoted through education/reward/special events/training and professional development of school staff/community partnerships
@@Parents are involved by taking suggestions regarding physical activity/their participation in school physical activity/involvement in planning and organizing events or facilities related to physical activity
**Promotion of healthy eating is done though sale or availability of healthy food in canteen/education in class and field trips/communication of healthy eating policies in school/training of teacher/community partnerships
^Parents are involved by taking their suggestions/discussions regarding healthy eating
Figures in parenthesis denote percentages

4.3.3.4. Cluster

Table 4.59 provides the distribution of children according to their nutritional status across the three clusters. The nutritional status of children was significantly different across three clusters. The overall prevalence of severe thin/thin children in the study sample was 22.5 per cent, out of which the highest prevalence lied in the second cluster (28.7%). In turn, significant differences were seen among the key characteristics of the three rural clusters (Section 1). These include socio-demographic, socio-economic, living conditions, environmental hygiene and health indicators. Hence, these may contribute to the differences in the BMI of children, considering cluster of residence being a significant determinant of BMI among children.

Table 4.59: Distribution of children (6-12 years) according to the cluster of residence in different BMI categories

Cluster	Severe thinness & thinness (n=128)	Normal & Overweight/Obese (n=442)	p value*
Cluster 1 (n=200)	38 (19.0)	162 (81.0)	0.04
Cluster 2 (n=192)	55 (28.7)	137 (71.4)	
Cluster 3 (n=178)	35 (19.7)	143 (80.3)	
Total (n=570)	**128 (22.5)**	**442 (77.5)**	

*p-value on the basis of chi-square test
Figures in parenthesis denote percentages

Cluster was representative of a group of children who were residing in different locations of the surveillance site. The place of residence has an impact on the opportunities for education and occupation, availability of food items in the neighborhood, structured built environment of the neighborhood. These indicators further facilitate or inhibit household purchase behavior, physical activity of children, dietary intake of children and thus their BMI. The significant differences across various domains have been discussed in Section 1 and section 2. These differences in various indicators across the three rural clusters could have played a role in determining the BMI of children.

4.3.4. Multivariate analysis

In the present study, the three rural clusters were significantly different with respect to their socio-demographic profile, socio-economic profile, living conditions and environmental hygiene indicators. There was a high prevalence of thin/severe thin, stunting/severe stunting, and stage 1 and 2 hypertension among children (6-12 year old) residing in rural area. These children also had a high intake dietary energy (kcal) with higher contribution of carbohydrates and fats to total energy. The children in the first cluster had a higher score for appetitive stimuli (BAS). The food environment of the child at the household level, community level and school level was very diverse across three rural clusters.

This section discusses the predictors of BMI among children (6-12 year old) residing in three rural clusters. The multivariate regression models were developed at individual level;

household level and community level (Table 4.60). Step down logistic regression approach was adopted to arrive at different models. The variables which were at p<0.1 value in the bi-variate analysis were included in the initial model and variables were removed in a stepwise manner to arrive at the final model for the level and the final combined model.

Table 4.60: Multi-variable regression models explaining the individual level, household level and community level determinants of BMI of children (6-12 years old) residing in three rural clusters

Determinants	M1/M2/M3		Combined model*	
	OR (95% CI)	p-value**	OR (95% CI)	p-value**
Model 1 (M1): Individual level				
Age group (>10 to 14 years)	2.1 (1.1-3.8)	**0.02**	2.3 (1.1-4.8)	**0.0**
Fat intake (g)	0.99 (0.97-1.0)	0.56		
Carbohydrate energy per cent (%)	0.90 (0.79-1.0)	0.17		
Fat energy per cent (%)	0.87 (0.72-1.0)	0.10		
Intake of sweets (g)	1.0 (0.99-1.0)	0.35		
Met minutes-Television watching	0.99 (0.99-1.0)	0.94		
Sleep duration (minutes)	1.0 (0.99-1.0)	0.24		
BAS Score	1.1 (1.0-1.1)	**0.009**	1.0 (1.0-1.1)	0.17
Active mode of transport to school	1.4 (0.66-3.07)	0.36		
Model 1:- p-value:0.003; Adjusted R^2:0.08				
Model 2 (M2): Household level				
Open field for toilet use	0.7 (0.3-1.5)	0.33		
Mother education less than 5 years	1.3 (0.6-2.9)	0.47		
Socio-economic status *(Rich as base)*				
Middle	2.0 (0.8-4.9)	0.12	1.2 (0.5-3.1)	0.64
Poor	3.5 (1.2-10.4)	**0.02**	1.8 (0.7-4.9)	0.25
Per capita milk availability	1.0 (0.9-1.0)	0.66		
Per capita fat availability	0.9 (0.9-1.0)	0.14		
Total food expenditure (INR)	1.0 (0.9-1.0)	0.79		
Total % expenditure on sugar	1.1 (0.9-1.1)	0.06		
Model21:- p-value:0.01; Adjusted R^2:0.09				
Model 3 (M3): Community level				
Cluster *(First as base)*				
Second	1.3 (0.5-3.5)	0.54	3.9 (1.2-12.8)	**0.02**
Third	1.1 (0.5-2.6)	0.82	3.4 (0.9-12.2)	0.06
School of study *(Local government school as base)*				
Private school (village)	0.5 (0.2-1.2)	0.10	0.9 (0.3-2.5)	0.84
Private school (block/district)	0.4 (0.2-0.9)	**0.03**	0.4 (0.1-1.2)	0.09
Average hours of food availability	1.0 (0.9-1.2)	0.68		
Presence of traffic calming devices	2.6 (1.1-6.3)	**0.03**	2.1 (0.7-6.1)	0.2
Presence of stray animals	1.4 (0.7-2.9)	0.30		
Model 3:- p-value:0.01; Adjusted R^2:0.08			***Combined Model:-*** **p-value:0.0009; Adjusted R^2:0.144**	

*Determinants significant at p-value less than 0.05 in M1/M2/M3 has been taken in combined model
**p-value as estimated by Multi-variable logistic regression
Variables shaded in grey are not included in the combined model

The significant predictors of BMI among children at **individual level (M1)** included age more than 10 years old (OR: 2.1; 95% CI: 1.1-3.8) and total BAS score (OR: 1.1; 95% CI: 1.0-1.1). This showed that in children more than 10 years of age, BAS score i.e., appetitive stimuli played a role in defining the nutritional status of a child.

For the purpose of multi-variable analysis tertiles of socio-economic class were considered in place of quintiles. The significant predictors at the **household level (M2)** include poor socio-economic class (OR: 3.5; 95% CI: 1.2-10.4). This analysis showed that child (6-12 years) residing in a household with the poor socio-economic status has 3.5 times higher probability of getting thin/ severe thin as compared to children residing in a rich household. The household level food availability and purchase behavior though different among the households of two groups of children, did not predict the BMI of children (Table 4.60). In addition, though maternal education of less than 5 years and percentage total expenditure on sugar at the household level have higher odds of predicting the BMI of children but could not reach the level of significance.

In the third regression model of the **community level (M3)**, only school type and presence of traffic calming devices had protective effect on the child getting thin/ severe thin. Table 4.60 showed that in the community level model (M3) of BMI, the cluster of residence does not predict BMI of children.

However, in the **combined model** children residing in second cluster had significant odds of getting thin/ severe thin (OR: 3.9; 95% CI: 1.2-12.8). The combined model showed that child from the older age group of 10-14 years and residing in second cluster had a higher probability of getting thin/ severe thin. The three rural clusters were significantly different from each other for various aspects (Section 1).

There could be a probability of the interactions between various factors which interacted resulting in second cluster emerging as a significant predictor of BMI among children residing in rural areas. These factors could possibly include the differences in socio-demographic profile, socio-economic profile, living conditions, environmental hygiene indicators. Considering this probability, another combined model was developed which incorporated the interactions between factors interplaying at cluster level. Interactions between various factors like maternal education, use of toilet facilities, household construction, location of keeping domestic animals, type of household ventilation, built environment indicators explaining hygiene and socio-economic status, waste disposal mechanism and socio-economic class did not help in predicting the BMI of children. The comprehensiveness of the socio-economic scale used in the present research study could be the determining factor. The construction of the socio-economic status includes the following variables: education, occupation, family typology, household characteristics (household ownership, household construction, toilet facility, source of light, fuel used for cooking, source of drinking water, availability of kitchen), economic (availability of land, ownership of assets and livestock) and social (social status in the community) characteristics of the households.

Table 4.61: Combined Multi-variable regression models explaining the determinants of BMI of children (6-12 years old) residing in three rural clusters

Determinants	**Complete sample (CM1) (n=292)**		**Males (CM2) (n=147)**		**Females (CM3) (n=145)**	
	OR (95% CI)	**p-value****	**OR (95% CI)**	**p-value****	**OR (95% CI)**	**p-value****
Age group (>10 to 14 years)	2.1 (1.0-4.4)	**0.04**	1.9 (0.6-5.6)	0.24	3.7 (1.2-11.6)	**0.03**
Category and SES interaction *(Majority and Rich class as base)*						
Majority and Middle class	1.2 (0.5-3.0)	0.67	1.3 (0.3-4.7)	0.73	1.2 (0.3-4.6)	0.30
Majority and Poor class	0.8 (0.2-3.2)	0.79	0.9 (0.1-7.4)	0.99	0.7 (0.1-4.6)	0.70
Minority and Rich class	1.3 (0.2-8.4)	0.77	Empty		Empty	
Minority and Middle class	0.9 (0.2-3.9)	0.94	1.04 (0.17-6.5)	0.96	1.1 (0.1-11.3)	0.97
Minority and Poor class	4.4 (1.6-12.1)	**0.004**	3.5 (0.8-14.8)	0.08	6.3 (1.3-30.8)	**0.02**
Availability of cereal	0.9 (0.8-1.0)	0.048	0.9 (0.8-1.1)	0.33	0.9 (0.7-1.0)	0.06
Availability of sweets	0.9 (0.8-0.99)	0.025	0.9 (0.9-0.99)	**0.017**	0.9 (0.9-1.0)	0.22
Poor street condition	0.3 (0.1-1.1)	**0.07**	0.4 (0.06-2.0)	0.24	0.3 (0.06-1.6)	0.17
Sex *(Male as base)*						
Female	0.9 (0.5-1.9)	0.838				
	Combined Model 1: p-value:0.0001; Adjusted R^2:0.1562		***Combined Model 2:*** p-value:0.045; Adjusted R^2:0.1080		***Combined Model 3:*** p-value:0.04; Adjusted R^2:0.0934	

Table 4.61 explains the final model representing the interactions and other determinants of BMI. The following combined models were developed: sex adjusted combined model, combined model for males and combined model for females. In the sex adjusted combined model, the children >10 years (OR: 2.1; 95% CI: 1.0-4.4), minority category

residing in poor households (OR: 4.4; 95% CI: 1.6-12.1), availability of cereals (OR: 0.9; 95% CI: 0.8-1.0) and sweets (OR: 0.9; 95% CI: 0.8-0.99), and poor street condition (proxy indicator of the hygiene and cleanliness in the neighborhood) (OR: 0.3; 95% CI: 0.1-1.1) were significant determinants of the BMI among children. All the factors like significantly contributed in explaining the variability governing the BMI of children (p-value: 0.0001; Adjusted R^2: 0.156). This shows that the risk factors for getting thin/severe thin in a rural community are more than 10 years of age, living in a minority household of a poor socio-economic status, low availability of food at the household level and poor neighborhood environment.

The sex unadjusted combined model for male child showed that only availability of sweets at home played a significant role in determining BMI of the child. The same combined model for females (unadjusted for sex), showed that female child of more than 10 years of age had 3.7 times higher significant odds (95% CI: 1.2-11.6) and of a minority category residing in a household with poor socio-economic class had 6.3 times higher significant odds (95% CI: 1.3-30.8) of getting thin/severe thin as compared to a normal/overweight female child belonging to a majority category residing in a rich household. This showed that the additional dietary needs, coupled with poor socio-economic conditions of the households of the female child on reaching puberty resulted in a significantly lower BMI as compared to a normal child. The results showed that females are more vulnerable for getting thin/ severe thin when provided the same environmental conditions though not significant in sex adjusted combined model.

Literature has shown that the BMI of the child is influenced by many factors. The relationship between the household level factors with the nutritional status among children (4-15 years) in Sub-Saharan Africa (SSA) has been estimated using multivariable data analysis. The household level resources in terms of the livestock and farms/fields had a significant negative relationship with the malnutrition status among children (4-15 years). The ownership of resources increases the reliance on the consumption of self-produced food like grains, fruits and vegetables and milk and milk products. Odds of chronic malnutrition was higher among the children where the households did not own any cattle (OR: 1.36; 95% CI: 0.72-2.56), children more than 10 years of age (OR: 3.12; 95% CI: 2.15-4.51), morbidity in terms of fever (OR: 1.62;

95% CI: 1.23-2.32) (Herrador et al, 2014). Green et al (2016) showed that increasing availability from various food groups at the household level significantly reduces the prevalence of stunting among children residing in the households. These food groups include vegetables, milk products, and sugars. Increasing urbanization of an area results in greater penetration of local food markets in an area results in higher availability of foods at the household level and improving the nutritional status of the children. Since, the increasing availability increases the dietary diversity of the food consumed by children (Darapheak et al, 2013; Rah et al, 2010). This dietary diversity in the food intake is in turn influenced by the production diversity at farm level in the rural areas apart from the increasing market availability (Sibhatu et al, 2015). Since, commercialization of the production diversity at the small holder farmer in rural area contributes to the concentration of food items available in the neighborhood market (Sibhatu et al, 2015). In the present study, the children were consuming a high calorie diet, which was a combination of traditional foods (milk, cereal and sugar) and modern foods (unhealthy food like sweets, fried snacks, bakery foods). The purchase behavior of the households showed that both market purchase and farm production contribute to the household level per capita availability of the particular food group.

In the present research study physical activity, sleep duration, dietary intake socio-demographic profile of the household, food expenditure, neighborhood built environment, community food environment and school environment were insignificant predictors of BMI among children (6-12 year old). It appeared that SES and minority status together took care of many of these variables and became composite indicator of under-nutrition of children aged 10-14 years in the present study along with home food availability and neighborhood environment. The multi-level modeling explaining the influence of different hierarchies (individual level, household level and community level) on the nutritional status of the child (6-12 years old) will be required to better understand the variables contributing to child under nutrition in this population. With these differences in environment in which the children were residing the major predictors of BMI include age (more than 10 years), interplay of socio-economic class with category, poor neighborhood conditions and household food security.

The role of hygiene and sanitation, socio-economic status and other demographic features were found as major driver of the nutritional status of children. This could be because of the factors interplaying at the household; neighborhood and school level inhibit or facilitate the dietary intake of children. In addition, with the development the mothers have started working which has resulted in meals consumed by the child with the intake of unhealthy foods. This intake of empty calories results in nutritional deficiency and impaired growth, which further results in under nutrition among children (Chaturvedi et al, 2016). However, the demographic features like defecation, environmental hygiene and living conditions influences the mal absorption and bioavailability of the consumed food. Hence, this process results in the poor nutritional status of children. George et al (2016) has reported that in rural Bangladesh unsafe disposal mechanism of child feces was significantly associated with the environmental enteropathy and reduces the child's WAZ and HAZ leading to impaired growth.

4.4. Strengths of the Study

- The planned study represents a unified approach of assessing the determinants of nutritional status (BMI) among children (6-12 year old) across different levels.
- The research study being a core community-based epidemiological study adds nutritional data across various domains.
- The major strength of the study was the robust methods which have been implemented for various assessments done as a part of the research study.
- The standardizations of food items for dietary data assessment at individual and household level were done comprehensively add to the appropriateness of the data presented.
- The data quality assurance was taken at every step to ascertain the precision of the data collected and analyzed in the research study.

4.5. Limitations of the Study

- The current research study was planned as a community-based "cross-sectional" study. Being a core epidemiological study the data collection of the recruited children (6-12 year old) was delayed due to community based issues. Thus, the age group of the children shifted from 6-12 years to 6-14 years only for the anthropometric and clinical assessments done among children.

- The lack of morbidity profile among children (6-12 year old) in the present research study acted as the major lacunae. Since in the present study there was a high prevalence of underweight children along with adequate intake of energy among children (6-12 year old), we cannot be certain about the reasons for under nutrition in the absence of morbidity data.
- The physical activity behavior of the children was assessed through questionnaires, which showed a large duration of residual time. The study was based in rural North India and many of the descriptions in the questionnaire did not adequately described activities of the rural children and hence we had placed these activities under the category of 'residual activity'. There is lack of a validated comprehensive compendium of metabolic equivalents for quantifying the physical activity a met minutes among Indian children.
- The community food environment was assessed to only map the stores and availability of food items in the food store. The quantity of food items, pricing strategies, variety available and promotional strategies used could have depicted more real picture of the neighborhood level food environment surrounding the households of the sampled children.
- The built environment around the households was chosen to be assessed in the 50 per cent sub-sample. This is due to the fact that the households of the sampled children (6-12 year old) are located at very closely spaced distance in a village. Thus, to avoid clustering of the neighborhood built environment data the assessment was done in the randomly chosen sub-sample.
- The school environment assessment was done in two schools (one private and one government) from each cluster. The scores of different indicators were then projected for the children studying in the government or private of the respective cluster.
- Data for various school environments was considered as missing for a large proportion of children who were studying in the private school (block/district).

Chapter 5
Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

5.1 Introduction

The burden of under and over nutrition is increasing rapidly in the country resulting in a dual burden, which often coexist in the same environment. The nutrition transition has resulted in dietary changes with increasing demand of unhealthy foods. The disparity in the motivated choice behavior of an individual, such as food, which is driven by both human and executive control functions instigated by the prevailing modern environment, has an impact on the eating behavior and the Body Mass Index (BMI). Additionally, changing pattern of occupation and associated mobility, infrastructure development and media have also influenced physical activity opportunities. The existing literature has majorly focused on unraveling the determinants and mediators of obesity-genetic, metabolic, psychological, behavioral and demographic. This has enabled us to understand the determinants and etiology behind the disease but has not helped us in understanding the solutions. Thus, there is an urgency to address the socio-cultural moderators of malnutrition and a holistic approach to understand the etiology behind it, which has been barely addressed in the current research paradigm.

5.2 Methodology

The present research study was designed as a community based “cross-sectional” study conducted among children (6-12 year old; n=612) residing in rural areas of Palwal district to study the determinants of BMI of children with a unified/multi-level approach. For evaluating the determinants of BMI of children residing in three rural clusters, assessments were conducted at three levels using various tools and techniques. The levels of assessment include: Individual level (6-12 year old child), Household level (place where the child resides) and Community level (neighbourhood and surrounding area of the household where child resides).

5.3 Key Results of the Study

5.3.1 Description of Three Rural Clusters

Socio-Demographic Profile: The first cluster had a higher proportion of working age population (19-45 years) and more than 98 per cent of the population was following Hinduism. It also had a higher proportion of population (both males and females) who have completed higher education (more than 8 years of schooling). Around 42 per cent of the male population was working in the service sector (government/private) and one-fifth of the females (21.7%) were involved in some kind of occupation outside home. The second cluster being on the National Highway had a highly dense population with 1472 persons living per square kilometer of the area. The majority of the population in the second cluster belonged to Muslim religion (74.9%) along with the higher proportion of illiterate population among both males and females (>18 years of age). A lesser proportion of females were found to be working outside home, and around 40 per cent of males (>18 years of age) were working as skilled / manual labor/ in business/professionals. The third cluster situated in the Mewat region near the Nuh-Hodal state highway was sparsely populated with only 586 people living per square kilometer. In the third cluster more than 55 per cent of the population belonged to the Hindu religion. There was an approximate equal distribution of farming and service sector as occupation profiles among male members of the household (>18 years of age).

Socio-Economic Profile: The first cluster had a higher proportion of households with a high and upper middle class socio-economic status. It was also found that there were a higher proportion of earning members in the family, in more than 80 per cent of the households some member had a bank account, nearly 80 per cent of the houses had a "pucca" construction. The highest proportion of households had ownership of commercial land, inverter and LPG connection. The second cluster had a high proportion of poor and lower middle class households with only one earning member in the family in more than half of the households (57.9%).Almost all the families (96.7%) had a self-owned household and more than one-third of the households had "kuchha" and "mixed" type of household construction (35.7%). The households in the third cluster belonged to all classes of socio-economic status. More than 50 per cent of the households owned agricultural land (52.8%) and around one-fifth of the households owned non-agricultural land for any other purpose (19.7%). Nearly all the families were living in a self-owned household (99.4%); two-third of the households (63.2%) had a *"pucca"* type of household construction. In more than half of the households (57.1%) only one family member was earning and there was also found the highest proportion of households having ownership of domestic animals.

Living Conditions: The first cluster had significantly better living conditions as compared to the poor living conditions of the households in the second and third cluster as assessed using following indicators: location of kitchen, presence of bathroom, number of sleeping in the room, proof of smoke in the household, location of keeping domestic animal, presence of animal shed, and place for washing clothes.

Environmental Hygiene: The first cluster despite having higher literacy rate, higher socio-economic status, better household living conditions had poorly placed environmental hygiene indicators, which in turn could have detrimental effects on the nutritional status of the population. The second cluster was poorest in its socio-economic profile, had highest prevalence of illiterate population, poor living conditions of the households, but most had a source of clean water for drinking and cooking water located within their dwelling unit. In the third cluster, the proportion of households using open field as a toilet facility was found to be higher along with the use of unclean sources of water for drinking/cooking food and open waste disposal mechanism.

Health and Care Seeking Behavior: Majority of the households (97.9%) frequented non-certified health facilities for the general care and treatment for children. The first cluster had the highest tobacco consumption and second cluster reported high alcohol consumption. The prevalence of chronic disease though very low was reported highest in the first cluster.

5.3.2 Description of Sample (6-12 year old)

Socio-Demographic and Socio-Economic Profile: The sampled households of the first cluster represented the dominance of Hindu religion in the community (98.0%) with two-third of the households with nuclear typology of family (64.5%). There was a higher proportion of lower middle class households (32.0%) among the recruited sample of first cluster. There was a mix of households with agriculture/livestock farming (42.1%) and service of any kind (45.1%) as their primary paternal occupation. Nearly, 36.2 per cent of the mothers had attained 5 years or more of education and 46.2 per cent of the mothers were engaged in some kind of employment which required spending more than 6 hours outside home. The sampled households of the second cluster represented the dominance of Muslim religion (61.3%) and a high proportion of upper middle and middle class households (47.1%). The rates of paternal and maternal illiteracy (38.4% and 81.3%) were highest in the second cluster. Agriculture/livestock farming was reported as the primary occupation in nearly 60 per cent of the households. There was an equal distribution among the mothers of the recruited sample who were engaged in any kind of occupation outside home (36.9%) vs. household chores (31.0%). In the third cluster there was a higher proportion of households with Hindu religion (66.7%), 44 per cent of the households had joint and extended family system. One-fourth of the recruited households (24.2%) represents the lower socio-economic class. Agriculture/livestock farming was reported as the primary paternal occupation. There was also high rates of paternal literacy (72.2%) and maternal illiteracy (77.5%). Most of the mothers of the recruited children (70.6%) were engaged in some kind of occupation outside home.

Anthropometric and Clinical Assessment: The median height, weight and BMI among children (6-12 year old) was 129.5 cm, 24.2 kg and 14.4 kg/m^2 respectively across all three clusters with significant differences between them. Prevalence of thinness/severe thinness and overweight/obesity in all three clusters was 22.5 per cent and 3 per cent respectively. The children residing in the first cluster had a slightly higher prevalence of overweight and obesity. The children in the second cluster had a higher prevalence of underweight and stunting (69.0% and 22.4%) respectively. The median MUAC, waist circumference and hip circumference was 16.9 cm, 53.7 cm and 63.0 cm among young children (6-12 year old) with significant differences across the three rural clusters. The children in the third cluster had a high prevalence of hypertension (24.3%) as compared to the first (9.5%) and second (7.8%) cluster respectively.

Dietary Profile of Children: There were differences in the food group intake among rural children in three clusters and they had a higher intake of sugars (56.7g/d) and cereals and millets (247.6g/d) as compared to their age and gender specific recommendations. The milk intake was also high among children (338.3g/d), though not different among children in three rural clusters. The pulse intake was significantly lower among children in third cluster (16.8g) vis-à-vis the children in first (22.3g) and second cluster (21.7g). The median energy intake among children was higher than the RDA (ICMR, 2010) but did not reflect any cluster level differences. However, there were differences in the percentage contribution of different macronutrients to the median energy intake across three rural clusters. In the first cluster, there was significantly higher fat contribution (30.6 en%), in the second cluster there was a significantly higher contribution of carbohydrates (60.6 en%) and in the third cluster, there was a significantly higher contribution of proteins (10.4 en%) to the energy intake. Unhealthy foods were found to be contributing one-fifth of daily energy intake among rural children (21.3%) with significant differences across three rural clusters.

Physical Activity Profile: The physical activity profile and sleep behavior of children (6-12 year age old) residing across three rural clusters was significantly different. Children residing in the first cluster were more sedentarily active (74.0%) and were engaged in less met minutes of physical activity (2246.2; 95% CI: 2192.3-2300.4) throughout the day as compared to children in other two clusters. The children residing in the first cluster had higher met minutes of physical activity for TV viewing (112.5 met minutes) and residual time (948.4 met minutes) and least for sleep (486.0 met minutes). The children in the second cluster were engaged in 2566.6 met minutes (95%CI: 2432.9-2677.9) of total physical activity. The children were spending more time in leisure time activities and household chores as compared to children residing in other two clusters. The proportion of children in the third cluster found to be vigorously active was 63.8 per cent according to their PAL, significantly higher as compared to first (6.5%) and second cluster (25.8%) respectively.

Eating Pattern Phenotypes: The total BAS score were significantly different among children residing in the third cluster as compared to the first and second cluster. The BIS score was found to be significantly lower among children residing in the third cluster as compared to the children in other two groups. There were no differences in the proportional scores of restraint eating among children (6-12 years across three clusters). The median proportion of the external eating score of the total eating behavior score among children (6-12 year old) was significantly higher among children of the second cluster and emotional eating scores were higher among children residing in the first cluster as compared to the children residing in the second and third cluster.

Household Food Availability and Purchase Behavior: The food availability of different food groups was significantly different among the households in three rural clusters. The per capita monthly availability of pulses and legumes (366.7 g), milk and milk products (11.9 kg) and fruits and vegetables (5.2 kg) was significantly higher in the households in the first cluster as compared to the households in second and the third cluster. However, on the other hand the per capita monthly availability of meat, fish and poultry (64.3g) and unhealthy foods (1187.2g) was found to be significantly higher among the households in the second cluster. The market purchase frequency of healthy foods (90 times per month) was found to be significantly lower in the households of the first cluster (81.5 times per month) as compared to the second cluster (93 times per month) and third cluster (96 times/month) respectively. The money spent on market purchase of fruits and vegetables and sugar and sugar products was found to be significantly higher among the households of the second cluster as compared to the first and second cluster. The households in the third cluster (216 INR/month) spent significantly less on the unhealthy food (salty and fried snacks, bakery products and beverages) as compared to the households in the first (299 INR/month) and second cluster (410.5 INR/month) respectively.

Built Neighborhood Environment: The households in the first cluster perceived their neighborhood as highly dense with poor infrastructure and aesthetics, unsafe from high flow of traffic and stray animals as compared to the second and the third cluster.

Community Food Environment: Of all the food stores mapped and assessed in the three rural clusters 70 per cent of the food stores were fixed, 20 per cent were mobile stores and 9 per cent were fixed mobile stores. The Store Health Index was similar across three rural clusters with median index score of "1.0" but with significant difference across three rural clusters. However, in the second cluster the food access to the households was for the longer durations (12.3 hours) as compared to the first (10.2

hours) and the third (11.4 hours) clusters respectively. The third cluster has significantly lower retail density (9.2 stores per 1000 population) as compared to the first (10.7 stores per 1000 population) and second (12.1 stores per 1000 population) cluster.

School Eating and Physical Activity Environment: A large proportion of the sampled children were studying in the government school at the village level. The physical activity environment of the school was significantly different ($p<0.05$) among the three rural clusters. The third cluster had better facilities, equipment, physical activity instructors and enhanced strategies for physical activity promotion in schools. The children studying in the schools located in the first cluster had access to canteen/convenience store (34.1%) and facilities for eating in school as compared to no canteen and facilities in the second and third cluster.

5.3.3 Determinants of BMI of Children (6-12 years)

In order to identify the determinants of BMI, the children were classified into two groups – thin/severe thin (n=128) and normal and overweight/obese (n=128). Since the prevalence of obesity was only 3 per cent, the obese children were pooled with the normal children for analysis purposes**.**

5.3.3.1 Individual Level

Age and Gender: There were significant differences in the nutritional status of children among different age groups. In the 10-14 years of age group, there was a higher prevalence of thinness/severe thinness (59.4%) as compared to the younger age group (40.6%). However, there were no significant differences in the status of thinness/severe thinness across gender.

Food Group Intake: There were no significant differences in the intake of different food groups among thin/severe thin and normal/overweight children (6-12 years old) except fat intake. However, the quantity of food intake among normal/overweight children was higher as compared to thin/severe thin children. The fat intake among thin/severe thin children was 22.5g/d as compared to 27.3g/d among normal/overweight children ($p<0.05$).

Intake of Unhealthy Foods: The median intake of sweets and confectionaries among thin/severe thin and normal/overweight children was 33.9g/d and 41.6g/d respectively. However, the median per day intake of sugar-based dishes was higher among severe thin/thin children (33.7g/d) as compared to normal/overweight children (26.6g/d). There were no significant differences in the frequency of consumption of various unhealthy foods between both the groups of children.

Energy (kcal) and Macronutrient Intake (g): The median dietary energy of the severe thin/thin children was less (1933 kcal) as compared to the normal/overweight children (2171.6 kcal). In addition, there was a significant difference in the total fat intake between both the groups of children. The thin children had a significantly higher energy per cent (en %) derived from carbohydrates and lower energy per cent from fats vis-à-vis the normal/overweight and obese children. Carbohydrates contributed 62.2 per cent energy among thin/severe thin children as compared to 58.5 per cent among normal children.

Physical Activity Profile and Sleep Behavior: There were no significant differences in the total met minutes of physical activity and the PAL of the children (6-12 year old) in different BMI categories. Moreover, there were significant differences in the mode of transport used by children (6-12 year old) for travelling to school. However, the met minutes of physical activity was significantly different for TV watching and sleep among children in different BMI categories. The severe thin/thin children had a 15 minutes higher duration of sleep and the duration of television watching was higher among normal/overweight children.

Eating Pattern Phenotypes: The BAS scores of the thin/severe thin children (6-12 year old) was significantly higher ($p<0.05$). There was no significant difference found in the external and emotional behavior of the children (6-12 year old).

5.3.3.2 Household Level (Proximal Determinants)

Household Characteristics: In the current study, there was significantly lower prevalence of thin/severe thin children in the households where mothers were educated i.e., who had attained education higher than 5 years of schooling (17.0%) as compared to the mothers who were illiterate or have basic primary education (24.5%). Households where defecation was done in open fields had a significantly higher prevalence of thin/severe thin children (26.8%) as compared to the households where constructed toilet was used for defecation (19.7%). The higher proportion of thin/severe thin children resides in households of lower middle class and poor class (41.4%) as compared to the normal/overweight children (29.2%).

Household Food Availability: The per capita per month availability of the different foods of various food groups in the households of normal/overweight children was significantly higher vis-à-vis thin/severe thin children. These food groups include pulses, milk and milk products, fats and oils and sweets and confectionaries.

Purchase Behavior: The purchase frequency of food items was higher in the households of severe thin/thin children as compared to the households of normal/overweight group children, but there were no significant differences between two groups. In the households of normal/overweight children, 1038.8 INR was spent on the food from all sources as compared to 751.0 INR in the households of thin/severe thin children ($p<0.05$). Apart from the total expenditure, there were also significant differences in the percentage expenditure on sugars and sweets/confectionaries among the households of two groups. The households of thin/severe thin children were spending 9.4 per cent of their total household expenditure on sugars and its products as compared to 6.7 per cent of the normal/overweight children households. In addition, the major striking observation was that the percentage expenditure on milk and milk products was higher among normal/overweight households by 10 per cent as compared to thin/severe thin households. While the total food expenditure was significantly higher ($p<0.05$) in normal/overweight group of children, there were no significant differences in the market food expenditure of the households of children in two groups.

5.3.3.3 Community Level (Distal Determinants)

Neighborhood Built Environment: There were no significant differences in the scores of different attributes of built environment neighboring the households of children in the two groups.

Community Food Environment: The average duration for which food was available in the neighborhood environment of thin children was higher by 42 minutes, though differences were not statistically. The retail density of the food stores in the neighborhood was higher for thin/severe thin children as compared to normal/overweight children, though not significant.

School Eating and Physical Activity Environment: There was a significant difference in the type of school in which the child studied and the nutritional status of the child. There were no significant differences in the school environment of children according to their nutritional status, although the school environment was significantly different across three rural clusters with higher promotional strategies and facilities for physical activity available in the third cluster and canteens/convenience store available in the first cluster.

Cluster: The nutritional status of children was significantly different across three clusters. The overall prevalence of severe thin/thin children in the study sample was 22.5 per cent, out of which the highest prevalence lied in the second cluster (28.7%). Obesity prevalence, though low, showed no significant difference across clusters.

5.3.3.4 Multivariate Analysis

In the combined model of the multivariate analysis, children residing in the second cluster had significant odds of getting thin/ severe thin (OR: 3.9; 95% CI: 1.2-12.8). The combined model showed that child from the older age group of 10-14 years and residing in the second cluster had a higher probability of being thin/ severe thin. There could be a probability that the interactions between various factors resulted in the second cluster emerging as a significant predictor of BMI among children residing in rural areas. Therefore, in the sex adjusted combined model to study the interactions, the children >10 years (OR: 2.0; 95% CI: 1.1-3.7), minority category residing in poor households (OR: 3.6; 95% CI: 1.4-9.3) and presence of traffic calming devices (an indirect indicator of quality and safety of the neighborhood) (OR: 2.5; 95% CI: 1.0-6.0) were significant determinants of the BMI among children. The other factors like contribution of fats to the total energy and gender were insignificant, but, significantly contributed in explaining the variability governing the BMI of children (p-value: 0.0006; Adjusted R^2: 0.0934).

The sex unadjusted combined model for male child showed that only contribution of fats to the total energy intake played a significant role in determining BMI of the child. The same combined model for females (unadjusted for sex), showed that female child of more than 10 years of age had 2.5 times higher significant odds (95% CI: 1.1-5.6) and of a minority category residing in a household with poor socio-economic class had 6 times higher significant odds (95% CI: 1.5-23.8) of getting thin/severe thin as compared to a normal/overweight female child belonging to a majority category residing in a rich household. This showed that the additional dietary needs of the female child on reaching puberty, coupled with poor socio-economic conditions of the households resulted in a significantly lower BMI as compared to a normal child. The results showed that females are more vulnerable for getting thin/ severe thin when provided the same environmental conditions.

5.4 Conclusion

In the present investigation, the children (6-12 year old; n=612) had higher intakes of dietary energy (kcal) as compared to the RDA with the one-fifth share of the calories being derived from the unhealthy foods. The high calorie diet, was a combination of traditional foods (milk, cereal and sugar) and modern foods (unhealthy food like sweets, fried snacks, bakery foods). The children were also involved in high levels of physical activity. Despite having a high energy intake, prevalence of obesity was low (3%) and a much higher proportion of the children were under nourished as per their BMI-for-age categories (22.5%). However, one-fifth of the children were placed in stage 1 and 2 hypertension. In the present research study, physical activity, sleep duration, dietary intake, community food environment and school environment were insignificant predictors of BMI among children (6-12 year old). The interactions of socio-economic status and the minority status, household food security and poor neighborhood environment of the household are the risk factors of getting undernourish among children aged 10-14 years. Overall, at the cluster level the cluster with a high and upper middle class socio-economic status have lowest prevalence of undernutrition and highest prevalence of overweight and obesity with the lowest proportion of minority population and low percentage contribution of unhealthy foods with low retail density. And the poorest cluster have a highest proportion of minority population, highest prevalence of undernutrition and lowest overweight and obesity, highest contribution of unhealthy foods to the total energy and highest retail density.

Hygiene and sanitation, socio-economic status and other demographic features were the major drivers of the nutritional status of children. Demographic features like defecation, environmental hygiene and living conditions influences the absorption and bioavailability of the consumed food resulting in poor nutritional status of children. Such factors interplaying at the household, neighborhood and school level also inhibit or facilitate the dietary intake of children. In addition, more mothers working outside home has resulted in greater intake of unhealthy foods in rural households. This intake of empty calories results in nutritional deficiency and impaired growth, which further results in under nutrition among children.

The increasing urbanization and development in the area. opportunities for the children to consume unhealthy foods were increasingly available in the increasing retail space of the area under development. Unhealthy food consumption among children has replaced the home cooked food in the child's dietary intake. This has resulted in the intake of high energy foods with poor nutrient density among children. The decreasing size of agricultural land and subsistence farming and increasing population density has resulted in an increasing dependency on the market to procure food items at the household level. This in turn has increased the per capita availability of food items at the household level. However, the poor hygiene indicators in terms of open defecation and living conditions coupled with the poor quality of diet results in increased infections, malabsorption of nutrients and thus poor nutritional status among children.

To conclude these rural areas in Haryana are undergoing developmental transition with increasing population density; congested living spaces; increased retail spaces and market food availability leading to erosion of traditional lifestyles and dietaries. In this area, the food intake of children of children has increased considerably without having any influence on the nutritional status of children. This is governed the increased availability of poor quality of food in the environment and poor hygiene and living conditions in which children are living. The changing lifestyles with the development results in an increasing intake of unhealthy foods influencing the nutritional status of children. Therefore, it is required for a further research study on studying the gut related factors, which are very critical in defining the nutritional status of children despite of having a high calorie diet.

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