ASSESSMENT OF DIETARY DIVERSITY AND ITS ASSOCIATION WITH NUTRITIONAL STATUS AMONG ADOLESCENTS OF ITAHARI SUB-METROPOLITAN CITY

by

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Assessment of Dietary Diversity and its association with Nutritional Status Among Adolescents of Itahari Sub-Metropolitan City

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Approval Letter

This dissertation entitled Assessment of *"Assessment of Nutritional Status and its Association with Nutritional Status among Adolescent of Itahari Sub-Metropolitan City" Sunsari* presented by Prechhya Karki has been accepted as the partial fulfillment of the requirement for bachelor's degree in nutrition and Dietetics

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Abstract

Adolescence is a critical period of growth, making nutrition a key determinant of long-term health yet they are often overlooked in nutritional research national programs. Thus, this study aims to assess dietary diversity and its association with nutritional status among adolescents in Itahari sub-Metropolitan City. A cross-sectional study design was administered among 205 adolescents ages 10-19 years of age, selected using a multistage random sampling technique. Data collection involved anthropometric measurements and dietary assessments through a Dietary Diversity score and 24-hour dietary recall. Statistical analyses, including Chi-square and Fisher's exact tests, were applied to examine the association between nutritional status and selected socioeconomic as well as lifestyle variables.

The study revealed a notable burden of malnutrition, with of adolescents identified as 16.1% stunted and 14.1% thin, while overweight/obesity was observed in 4.8% of participants. Dietary inadequacies were also prominent, as73.7% reported insufficient energy intake, 41.5% Inadequate protein intake, and 73.7% inadequate fat intake. A significant proportion of adolescents had inadequate dietary diversity (72.7%), only 27.3% met the requirement. Factors such as age group (p=0.036), energy adequacy(p=0.0001), protein adequacy (p=0.04), fat adequacy (p=0.014) were significantly associated with stunting. Additionally, age group (p=0.019), religion (p=0.003), non-veg (p=0.036), energy adequacy (p=0.000), protein intake (p=0.000) and fat adequacy (p=0.000) were identified as significant predictors of poor BMI-for-age outcomes. This study highlights the urgent need for targeted interventions to improve dietary practices and nutritional education among adolescents.

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List of Abbreviations

Abbreviations	Full Forms
AMDR	Acceptable Macronutrient Distribution Range
BMI	Body Mass Index
cm	Centimeter
CHO	Carbohydrate
DFTQC	Department of Food Technology and Quality Control
DD	Dietary Diversity
DDS	Dietary Diversity Score
EAR	Estimated Average Requirement
FAO	Food and Agriculture Organization of United Nations
FFQ	Food Frequency Questionnaires
FFM	Fat Free Mass
FM	Fat Mass
GoN	Government of Nepal
g	Gram
HDI	Human Development Index
HDD	Household Dietary Diversity
ICMR	Indian Council of Medical Research
IDA	Iron Deficiency Anemia
IDDS	Individual Dietary Diversity Score
IOM	Institute of Medicine of National Academies

Kcal	Kilocalorie
Kg	Kilogram
mg	Milligram
MDD-W	Mean Dietary Diversity for Women
NCHS	National Centre for Health Statistics
NCD	Non-communicable disease
NDHS	Nepal Demographic and Health Survey
NHRC	Nepal Health Research Council
NLM	National Library of Medicine
NNMB	National Nutrition Monitoring Bureau
NIN	National Institute of Nutrition
SES	Socio-economic status
RDA	Recommended Dietary Allowance
SEAR	South East Asian Region
SD	Standard Deviation
UNICEF	United Nations Children's Emergency Fund
WHO	World Health Organization

Part I

Introduction

1.1 Background of study

Adolescence, according to WHO is defined as the transitional stage of life between childhood and adulthood, specifically between the age of 10 and 19 years, characterized by accelerated physical growth, hormonal changes, and evolving emotional and cognitive abilities. During this phase, adolescents begin to think more abstractly and critically, attempt to create their own identities, establish deeper social relationships and attachments and grow more independent and responsible(World health organisation, 2025). Around 16% of the world's population are adolescents and about 20% of them live in the South-East Asia region (SEAR)(WHO., 2022). About 22% i.e. 6.38 million of Nepal's total population are adolescents of 10–19 years' age (G. Pokharel, 2017).

Globally, 390 million children and adolescents, ages 5 to 19 years are classified as overweight, with 160 million experiencing obesity. Additionally, around 190 million are affected by thinness, defined as BMI-for-age that is more than two standard deviations below the WHO reference median. These figures reflect a notable rise over the years, with the prevalence of overweight in this age group increasing from 8% in 1990 to 20% by 2022. Estimates suggest that only 1 in 5 teenagers report they are physically active enough to meet WHO guidelines. Across all WHO regions, inactivity is common, and prevalence is greater than male adolescent(WHO, 2022).

Nutritional vulnerability increases in adolescence due to heightened nutritional requirements, yet the quality of the diets consumed by this age group often deteriorates significantly. Adolescents both locally and internationally are frequently observed to have poor food habits and inadequate nutritional intakes (Moore Heslin and McNulty, 2023). Research indicates that teenagers living in low-income environments frequently lack access to a variety of foods, where diets are based predominantly on starchy staples which lack essential micronutrients which contribute to the burden of malnutrition and micronutrient deficiency. Dietary diversity is crucial for vulnerable adolescents, as it ensures they receive essential nutrients for growth, development, and overall health(Isabirye *et al.*, 2020) (Gonete *et al.*, 2020).

Although infectious and injury-related factors contribute to the burden of disease in adolescents, undernutrition, inadequate linear development, and nutritional deficiencies are serious public health issues (Christian and Smith, 2018). During puberty, adolescent have higher requirement of proteins, vitamins, and minerals to support rapid weight gain and skeletal growth (Rao *et al.*, 2007). According to WHO many school aged adolescent population in South-East Asia Region (SEAR) bears the triple burden of malnutrition 22% adolescents underweight, 8% overweight and high prevalence of nutritional deficiencies like iron deficiency anemia (WHO., 2024). Their general health, development, growth, and academic performance are all significantly impacted by this problem(WHO, 2006). An adolescent nutrition survey from 13 districts representing Nepal's three ecological regions revealed that 71% of male adolescents and 59% of female adolescents were undernourished, per the NHRC's 2014 nutrition survey(Aryal *et al.*, 2016).A study conducted in Jajarkot District showed the prevalence of stunting, with a rate of 42.5% among girls and 37.2% among boys, whereas overweight and obesity standing at 1% for boys and 2.2% for girls (R. Pokharel *et al.*, 2024). A cross-sectional analytical study carried out among school adolescents in Tanahun District, Nepal showed the prevalence of underweight and overweight/obese was 18.3% and 3.7% respectively (Mishra and Thapaliya, 2021).

1.2 Statement of the problem

Growth and development during adolescence are life-changing and have a significant impact on a person's health in later life as well as the health of any future children. There are currently more adolescents than at any previous point in history and are growing up in an era of an unparalleled and rapidly evolving food environment, climate change, urbanization marked by complex and persistent nutritional challenges such as micronutrient deficiencies, food insecurity and rising trend of overweight and obesity. This dual burden of malnutrition reflects significant shifts in dietary patterns and food availability, placing adolescents at an increased risk of both undernutrition and overnutrition (Norris *et al.*, 2022). The biological, behavioral, and social changes during adolescence are greatly supported by nutrition, highlighting the need to address nutritional concerns during this critical development period. Dietary habits and nutritional status are equally significant in shaping interpersonal dynamics within peer groups, families, and diverse ethnocultural setting (Achterberg and Shannon, 2020). Despite the critical nature and increased

nutritional needs, adolescents have been overlooked in national and global context, with the majority of nutrition interventions focusing on children and mothers(Aryal *et al.*, 2016).

Adolescents are particularly susceptible to nutritional deficiencies due to the heightened physiological demands of puberty. Inadequate nutrient intake during this critical growth phase can result in stunted development and long-lasting health complications extending into adulthood. For example, lack of dietary diversity and inadequate intake of essential nutrients is a significant problem among the poor populations of developing countries, where diets are based predominantly on starchy staples which lack essential micronutrients and contribute to the persistent burden of malnutrition and micronutrient deficiencies among adolescent(Gonete *et al.*, 2020). A study carried out in Nigeria has shown that 37.2% of the adolescents (males) were underweight compared to 20% of the females; whereas 5% of the adolescent females were overweight/obese compared to 2.9% of males. The above statistics demonstrate how urgently a thorough evaluation of adolescents' nutritional health is required in order to guide focused interventions(Abdulai *et al.*, 2023). A study conducted in Solukhumbu district has shown that majority of adolescent were underweight 53(27.6%), overweight 11 (5.7%) and obese 3(1.6%)(Sherpa *et al.*, 2019). In accordance to a Dang study, 25.7% of the teenagers were malnourished, with 18.3% being underweight, 3.% being overweight, and 0.8% being obese (Bhattarai and Bhusal, 2019). In eastern Nepal, a majority of adolescents were found to have abnormal body weight, with 47.3% underweight and overweight being 7.3%(Kafle *et al.*, 2020).

Given the high incidence of malnutrition and its substantial effects on teenagers' health and development, it is essential to conduct a survey to evaluate their dietary consumption and nutritional status. Since no study on dietary diversity and its association with nutritional status among adolescents in Itahari Sub-metropolitan city has been conducted till date, we aimed to assess the nutritional status and dietary diversity of the adolescents residing in Itahari Sub-metropolitan city. This study will yield vital information to improve educational programs, guide public health policies, and eventually boost adolescent wellbeing.

1.3 Objective of the study

1.3.1 General objective

- To assess the dietary diversity and its association with nutritional status among adolescents of Itahari Sub-Metropolitan

1.3.2 Specific objective

1. To assess the nutritional status of adolescents using anthropometric measurements
2. To study dietary diversity and its association with nutritional status
3. To assess knowledge of nutrition among adolescents
4. To study associated factors affecting nutritional status of adolescents

1.4 Research Questions

a) What is the existing nutritional status of adolescent aged 10-19 years of Itahari Sub-Metropolitan?

b) Are there any differences in nutritional status and dietary diversity among adolescents in Itahari Sub-Metropolitan

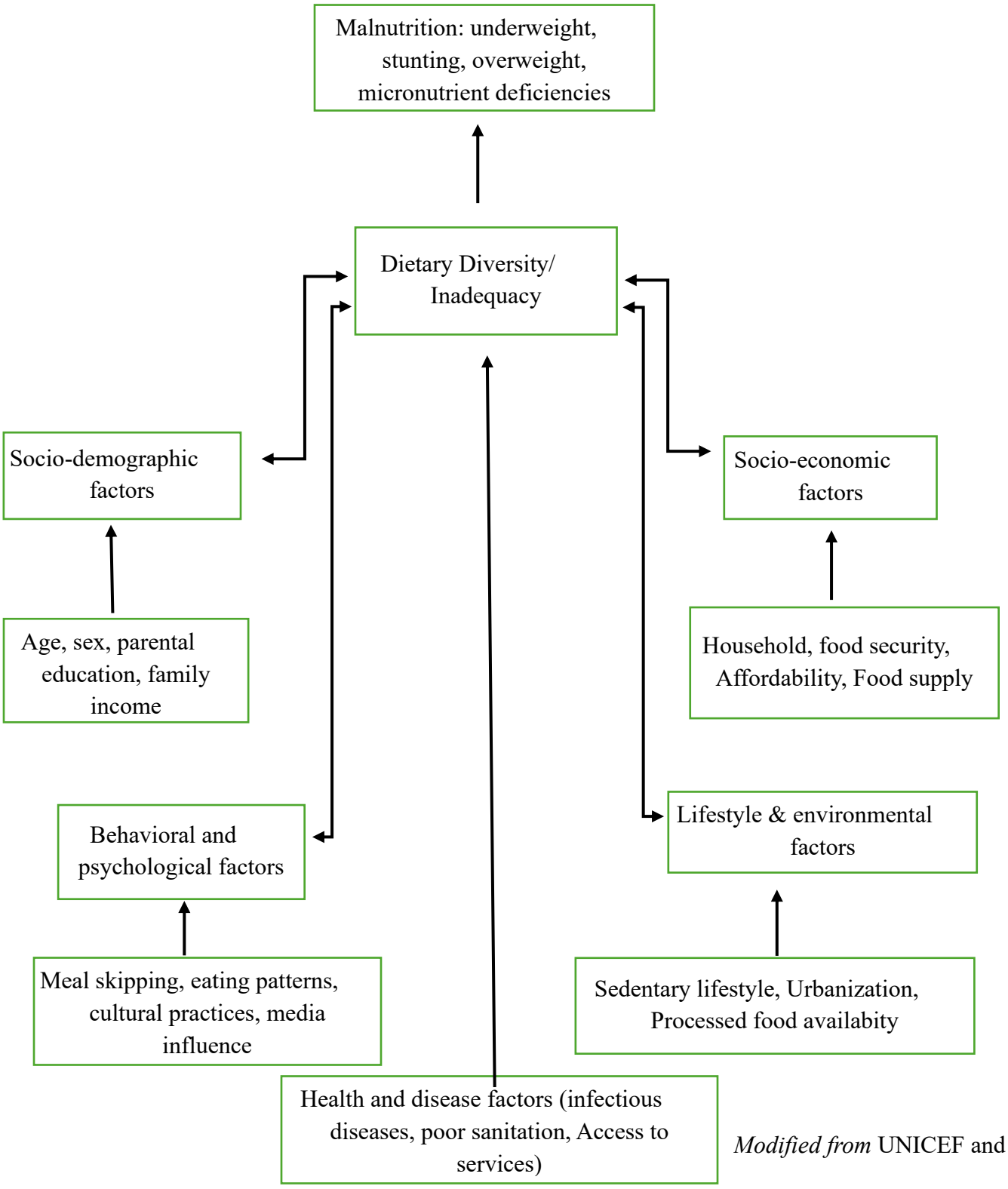
c) What is the level of nutritional knowledge among adolescents?

d) What are the different factors which influence the nutritional status of adolescents?

1.5 Significance of the study

- To determine the magnitude of malnutrition among school adolescents in Itahari Sub-Metropolitan city and provide evidence that can be generalized for further studies and interventions.
- To generate information on the nutritional status and related nutritional problems faced by adolescents in the community.
- To assess the level of dietary diversity among adolescents and its association with their nutritional status.
- To serve as a guide for the development of appropriate nutrition programs and policies in this community, based on the study findings.

1.6 Conceptual Framework



Modified from UNICEF and WHO

Figure 0.1 conceptual framework

1.7 Limitation of the study

- Since the study being cross-sectional in nature, dietary patterns and nutritional status can be affected by seasonal variation.

- Due to limited resources, biochemical and clinical tests are excluded.

Part II
Literature Review

2.1 Adolescence

Adolescence is the transitional stage between childhood and adulthood, typically covering the ages of 10 to 19 years. It is a period marked not only by rapid biological and physiological maturation but also by profound transformations in social roles, expectations, and responsibilities. Over the past century, both the biological and social dimensions of adolescence have evolved considerably, influenced by changing cultural, economic, and environmental contexts(Sawyer *et al.*, 2018). UNICEF 2011 has divided adolescence into two age groups i.e. early adolescents (10-14) and late adolescents (15-19).

2.1.1 Early adolescence (10-14 years)

Early adolescence can be defined as period between 10 and 14 years of age, during which significant physical changes begin, usually commencing with a growth spurt along with sexual characteristics. This stage is typically characterized by a rapid increase in growth, followed by the development of primary sexual organs and the emergence of secondary sexual characteristics (UNICEF., 2011).

2.1.2 Late adolescence (15-19 years)

Late adolescence, spanning the ages of 15 to 19 years, is a stage in which most primary physical developments have already occurred, although the body continues to mature. During this period, cognitive capacities such as critical and analytical thinking become more advanced as the brain undergoes further growth and restructuring. While peer influence remains significant in the earlier years of this stage, it gradually declines as adolescents develop greater self-confidence, identity, and independence (UNICEF., 2011).

2.2 Nutrition in adolescents

Nutrition is a scientific discipline that examines the relationship between food, the human body, and health. It explores how food provides nourishment, supports physiological functions, and affects overall well-being. In addition, the field of nutrition studies the determination of dietary patterns, develops recommendations regarding appropriate intake of different food groups, ensures food safety, and addresses challenges related to the global food system and supply chain (Thompson and Manore, 2009).

The dietary needs of adolescents during the puberty burst make them one of the nutritionally sensitive groups. The body's anabolic rate is extremely high at this point in order to reach 50% of their adult weight, more than 20% of their adult height, and 50% of their adult skeleton. Additionally, their need for macro or micronutrients is increased by growth, maturity, and other psychological factors, which results in malnutrition during a deficiency stage (Zememe *et al.*, 2019). This age group is consistently identified as failing to meet recommendations for a variety of nutrient that results in numerous short-term and long-term health issues, such as micronutrient deficiencies, an elevated risk of overweight or obesity, and an enhanced manifestation of cardiometabolic risk factors, can be brought on by inadequate nutrition during adolescence (Moore Heslin and McNulty, 2023).

2.3 Nutritional status

Nutritional status reflects the condition of an individual's body that results from the balance between nutrient intake and the body's nutritional requirements, along with the capacity to digest and utilize these nutrients effectively (Lohman *et al.*, 2008). Similarly, (Srihari *et al.*, 2007) define nutritional status as the adequacy of nutrient intake in terms of type and amount, which can be assessed through factors such as body composition, biochemical indicators, health conditions, and the capacity to consume and absorb food and also influenced by the amount of each essential nutrient that an individual consumes.

Adolescents' body size can serve as a good indicator of their nutritional condition; undernutrition can show up as stunting, wasting, or vitamin deficiencies without a change in body size, while overnutrition can show up as overweight and obesity(Das *et al.*, 2017).

2.4 Malnutrition

An excess or imbalance of energy and other macro- and micronutrients is referred to as malnutrition. It includes different levels of under- or over- nutrition, which alters bodily function, composition, and clinical results. Put another way, the term "malnutrition" refers to any state of inadequate nutrition, encompassing everything from severe hunger and undernourishment to obesity (Siddiqui *et al.*, 2020).

Malnutrition refers to three major categories of conditions:

a. Undernutrition: pathological condition caused by consuming insufficient amounts of food over an extended period of time is referred to as undernutrition. It encompasses being dangerously thin

for one's height (wasted), underweight for one's age, stunted (too short for one's age), and vitamin and mineral deficient.

b. Overnutrition: This pathological condition is brought on by an increased consumption of vital nutrients, especially calories, which is a current area of concern.

c. Specific deficiency: A pathological condition brought on by a partial or total absence of a particular nutrient(Joshi, 2017).

Nutritional status of adolescence in Nepal

A lack, surplus, or imbalance of energy and other macro- and micronutrients causes malnutrition, which changes the body's composition and function and has detrimental clinical effects. Nepal, one of the low-income countries in South Asia with a high rate of malnutrition, loses between 2% and 3% of its yearly gross domestic product due to vitamin and mineral deficiencies.

The census of 2021 indicates that in Nepal adolescent constitutes a significant portion of population, at nearly 24%. The gender distribution of these is 48.5% male and 51.5% female (statistics, 2021). These figures demonstrate how important adolescence are to Nepal's population as a whole.

According to Body Mass Index for Age (BMI), the prevalence of malnutrition among 15–19-year-old female adolescents was 26% thin and 10% overweight or obese, whereas the prevalence among male adolescents was 41% thin and 7% overweight or obese (MoHP, 2022). A school-based cross-sectional analytical study was conducted in the public secondary school of Lekhnath Municipality of Kaski District of Nepal showed according to body mass index, half of the respondents (50.6%) were found to be underweight with 38.3% being normal and 11.0% of them overweight (Puri and Adhikari, 2019). In a similar vein, a larger nationwide survey found that 79.5% of adolescent were underweight and that very few were within the normal weight range (Aryal *et al.*, 2016).

2.5 Factor affecting nutritional status of adolescence

a. Dietary adequacy

Adolescent growth and health are influenced by diet, and these effects persist into adulthood. During adolescence, inadequate intake of calories, macronutrients, or micronutrients may have detrimental long-term effects influencing growth potential, academic performance, and overall well-being. Additionally, disordered eating patterns like dieting or restriction, substituting

meal, fad foods, a negative weight perception, or a tense relationship with food can all be caused by adolescent malnutrition and lead to an inadequate diet (Evans and Doctor, 2020).

According to the review of 50 studies from 42 countries (2000-2014) on school children and adolescents (6-19Years) found that diets in developing countries are largely plant based with limited diversity, low fruit and vegetable intake, and insufficient energy and micronutrients. At the same time, there is a rising consumption of high-energy snacks and beverages, particularly in urban areas, reflecting a dual burden of malnutrition and the ongoing nutrition transition (Ochola and Masibo, 2014).

Similarly, a regional analysis demonstrated that adolescent in South-Asia face a triple burden of malnutrition, dietary patterns often fail to meet nutritional adequacy, with many adolescent consuming calorie-dense but nutrient poor foods.

b. Food Security

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life and food insecurity exists when people do not have adequate physical, social or economic access to food as defined above (FAO, 2002).

Children and adults in food insecure households frequently eat cheap, unhealthy food or modify their consumption by cutting back on quantities, skipping meals, or going without food. Research indicates that adolescents experiencing food insecurity, or living in food insecure households, are at higher risk of poorer general health, asthma, untreated dental problems, iron deficiency anemia, depression, mental disorders, dyslipidemia, and lower bone mass, and are less likely to receive preventive health(Dush, 2020).

A systematic review and meta-analysis were performed which indicated
that household food insecurity has been associated with higher risk of stunting and being underweight among children and adolescents. The likelihood of these conditions appears to rise with both the severity of food insecurity and the age of the child, indicating that older adolescents in food-insecure households are particularly vulnerable. Studies report that food insecurity increases the odds of stunting (OR = 1.17; 95% CI: 1.09–1.25) and underweight (OR = 1.17; 95% CI: 1.01–1.36), underscoring the critical role of household food access in shaping adolescent nutritional status (Moradi *et al.*, 2019).

c. Socioeconomic factors

Malnutrition has a disproportionately greater effect on people from underdeveloped and developing countries where poverty, lack of food security, and inadequate healthcare facilities allow the continuation of conditions that promote undernutrition as well as overnutrition (Saunders and Smith, 2010).

Food availability is greatly influenced by family income; higher-income families are more likely to be able to purchase a wide variety of nutrient-dense foods, whereas low-income households may have restricted access and must rely on less expensive, less nutrient-dense options(Mohd shariff *et al.*, 2015). A study carried out Bangladesh revealed that poverty and financial hardship (23.06%) ranked as most critical determinant of malnutrition among adolescents. According to later research, socioeconomic disparities exacerbate malnutrition in Bangladesh. While urban adolescents face the problem of overnutrition as a result of an inactive lifestyle and the availability of processed, high-calorie foods, rural adolescents are more likely to suffer from undernutrition due to poverty and limited access to healthcare(Redwan and Shabur, 2025).

Adolescents' lifestyles and diets have been found to be significantly impacted by parental traits such education level, social status, income, health, parenting style, stress, efficacy, habits, and preferences. An income gradient is evident in adolescent's weight status and diet, with greater deprivation linked to poorer diet quality and higher risk of overweight and obesity. Socioeconomic disadvantage limits financial freedom and choice, making adolescents more vulnerable to obesogenic environments(Moore Heslin and McNulty, 2023).

d. Physiological factors

Adolescence is characterized by bodily changes and the onset of puberty. Height gain, a change in voice, the emergence of secondary sexual qualities, the start of sex hormone development, body hair growth, the arrival of male and female menarches, and the escalation of sexual cravings are some of its distinguishing characteristics.

1.Growth spurt: The pubertal growth spurt accelerates linear growth, lean mass accumulation, and bone mineralization, thereby raising requirements for energy, protein, and micronutrients such as iron, calcium, and zinc (A. T. Soliman *et al.*, 2022). Normal puberty causes both height and weight to rise (adolescence accounts for 50% of adult body weight), as well as increases

in bone mass, muscle mass, blood volume, and the size of the heart, brain, lungs, liver, and kidney(Das *et al.*, 2017).

Nutritional status during adolescence not only influences body composition and final adult stature but also affects the timing of puberty. Undernutrition can delay pubertal onset and impair reproductive development, while excessive energy intake is linked to earlier menarche and increased risk of obesity and related disorders(Norris *et al.*, 2022)

2. Hormonal changes: These physiological processes are tightly regulated by the endocrine system—particularly the hypothalamic–pituitary–gonadal axis and the growth hormone–IGF-1 axis—both of which are highly sensitive to nutritional adequacy (Christian and Smith, 2018). Both testosterone and estrogen play important roles in sexual maturity and body composition, with testosterone encouraging lean mass and muscular growth in boys and estrogen influencing fat deposition in girls. Increased intake of calories, protein, and micronutrients is required since the surge in GH and IGF-1 speeds up linear development and improves nutrient utilization(A. Soliman *et al.*, 2014).

e. Environmental factors: Hygiene, water and sanitation: undernutrition is more common among populations living in unsanitary environments with poor water, sanitation, and hygiene (WASH), contributing to a significant share of the overall burden. Sanitation practices, including waste disposal and household cleanliness, play a crucial role in population health. Inadequate sanitation is linked to numerous infectious and nutrition-related conditions that contribute significantly to the global disease burden.

Diarrheal diseases remain the most prominent outcome, responsible for an estimated 1.4 million deaths each year. Repeated diarrheal episodes, helminth infections, and environmental enteric dysfunction impair nutrient absorption and gut health, even without visible symptoms. This creates a vicious cycle where diarrheal diseases deplete nutrients and water, leading to undernutrition, while undernutrition weakens immunity, increasing vulnerability that eventually compromise the nutritional status of children and adolescents and exposing them to recurrent subclinical infections from fecal pathogens(Freeman *et al.*, 2017) (Hernandez *et al.*, 2021).

f. Dietary behaviors and eating habits in adolescents

Food habits are the how, what, and when an individual or group of individuals or group of individuals eat. Maintaining a balanced diet is crucial to ensure that the body receives the

necessary nutrients to fiction optimally during this period of change. Adolescents often make independent food choices, and while healthy diets support growth and performance, poor habits can lead to underweight, overweight, or obesity (Baral *et al.*, 2025). Establishing healthy eating habits early is more effective than attempting to reverse harmful behaviors later in adulthood In low- and middle-income countries, a double burden of malnutrition persists, with inadequate diets coexisting alongside rising intake of cheap, nutrient-poor, energy-dense foods (WHO, 2021).

Fast food and processed foods have become more widely available, people are snacking more and eating meals out more frequently, while individuals are drinking more fast food and calorically sweetened beverages. These trends have been linked to chronic nutrition-related diseases like obesity(Moreno *et al.*, 2010).

Study carried out in Madhyapur Thimi municipality discovered that adolescents who regularly or occasionally ate junk food were more likely to be overweight. Overweight was less common among participants who ate fruits and avoided watching advertisements for fast food or carbonated soft drinks (Baral *et al.*, 2025).

g. Psychological factor

Identity development occurs during adolescence, which also includes changing the amount of time spent with parents and friends, forming new social bonds, becoming more independent, figuring out one's sexual orientation, etc (Redwan and Shabur, 2025).

A range of psychosocial factors such as attitudes, beliefs, self-efficacy, food preferences, mood, and mental health, along with biological determinants including appetite, taste, weight status, and allergies, strongly shaped adolescent eating behavior and dietary intake. During adolescence, rapid lifestyle changes, evolving eating habits, and heightened exposure to environmental influences further increase the nutritional vulnerability of this age group (Moore Heslin and McNulty, 2023). Even though parents can still serve as good role models, teenagers are typically heavily impacted by their classmates, their own dietary choices, and their evolving understanding of what makes up a sufficient and healthful diet (WHO, 2005).

2.6 Major nutritional problems in adolescence

2.6.1 Undernutrition

Undernutrition is defined by insufficient provision of energy and nutrients, such as good quality protein with an adequate balance of essential amino acids, vitamins and minerals, and an inability

to meet the requirements of the body to ensure growth, maintenance, and specific functions. It is the leading cause of death in children and has long-term physiological effects, such as insulin resistance in adulthood, decreased fat oxidation, decreased resting and postprandial energy expenditure, increased vulnerability to fat accumulation, primarily in the central region of the body, hypertension, dyslipidemia, and a diminished ability to perform manual labor, among other impairments(Martins *et al.*, 2011).

According to WHO undernutrition manifests in four broad categories: stunting, underweight, and micronutrient deficiencies(WHO, 2016).

a) **Underweight/Thinness**: The term "underweight" refers to a body weight that is too low to be deemed healthy for a typical adult, adolescent, or child; it can even affect older people. It has several different names, including wasting, emaciation, thinness, etc., and is brought on by a number of things, most notably the body's inability to absorb enough nutrition (Uzogara, 2016).

   More specifically, Adolescent thinness is defined as an equivalent Body Mass Index of less than 18.5 kg/m², poses serious risks to health and development. It is linked to stunted growth, delayed maturation, nutrient deficiencies, and reduced cognitive performance. Furthermore, thinness can increase the risk of osteoporosis, anemia, weakened immunity, reproductive complications, and higher mortality risk (Whitfield *et al.*, 2023).

b) **Stunting:** Stunting is defined as height-for-age lower than two standard deviations below the median. It is the result of chronic or recurrent undernutrition, usually associated with poverty, poor maternal health and nutrition, frequent illness and/or inappropriate feeding and care in early life. Stunting prevents children from reaching their physical and cognitive potential(WHO, 2016).

   Linear growth failure serves as a marker of multiple pathological disorders associated with increased morbidity and mortality, loss of physical growth potential, reduced neurodevelopmental and cognitive function and an elevated risk of chronic disease in adulthood. The severe irreversible physical and neurocognitive damage that accompanies stunted growth poses a major threat to human development (de Onis and Branca, 2016).

c) **Micronutrient deficiencies**: Micronutrient deficiencies are a lack of vitamins and minerals that are essential for body functions such as producing enzymes, hormones and other substances needed for growth and development(WHO, 2016)

2.6.2 Overweight/obesity

Overweight is a condition of excessive fat deposits whereas obesity is chronic complex disease defined by excessive fat deposits that can impair health. According to WHO,

Overweight and obesity are defined as follows for children aged between 5–19 years:

- Overweight is BMI-for-age greater than 1 standard deviation above the WHO Growth Reference median; and
- Obesity is greater than 2 standard deviations above the WHO Growth Reference median.

According to the Global Burden of Disease Study (1990-2021), overweight and obesity among children and young adolescents have more than doubled over three decades, with obesity alone tripling. North Africa and the Middle East (such as Kuwait and the United Arab Emirates) had the highest rates of overweight and obesity at the super-region level in 2021, whereas southeast Asia, east Asia, and Oceania saw the most increases between 1990 and 2021 (Collaborators., 2025).

Adolescents with obesity are at significantly increased risk for range of comorbid conditions. They are more likely to develop prediabetes and asthma, and the likelihood of hypertension is more than fourfold higher compared to their healthy weight peers. The most alarming association is with non-alcoholic fatty liver disease, where the risk is over twenty-six times greater. Furthermore, obese children and adolescents suffer psychological problems include eating disorders, anxiety, sadness, low self-esteem, and perceptions of weight and peer interactions.

These comorbidities underline the critical need for efficient prevention and intervention measures since they not only compromise health throughout adolescence but also pave the way for major chronic diseases in maturity (Zhang *et al.*, 2024).

2.6.3 Iron deficiency anemia

Anemia is a disorder when the hemoglobin concentration, or the quantity and size of red blood cells, falls below a predetermined threshold, hence reducing the blood's ability to carry oxygen throughout the body. The most common cause of anemia is thought to be iron deficiency; other causes include infections, both acute and chronic, which cause inflammation and blood loss;

deficiencies in other vitamins and minerals, particularly folate, vitamin B12, and vitamin A; and genetically inherited conditions, like thalassemia.

According to a comprehensive study conducted in rural Pakistan, 91% of late-adolescent girls had at least one iron, vitamin A, or vitamin D deficiency. This highlights the critical need for nutrition policies tailored to the needs of adolescents (Baxter *et al.*, 2021)

2.6.4 Vitamin A deficiency

Vitamin A deficiency (VAD) is a critical public health issue affecting adolescents, particularly in low- and middle-income countries. Though the risk of severe deficiency declines with age, vitamin A deficiency frequently extends into adolescence and further into early adulthood (Haider and Bhatia, 2006). Xerophthalmia, night blindness, anorexia, growth retardation, increased vulnerability to infections, blockage and proliferation of hair follicles, and keratinization of the skin's mucous epithelial cells due to a lack of proper differentiation are some signs of insufficiency(Gropper and Smith, 2013).

2.6.5 Other micronutrient deficiencies

Over half of an individual's bone mass develops during adolescence, making adequate calcium, vitamin D, and magnesium are critical for bone health. Yet, inadequate intake of these nutrients is highly prevalent among adolescents in Western world, with 70-95% deficient in vitamin D, 45-73% calcium, and 33% in magnesium. Adolescent girls are particularly vulnerable, placing them at greater risk of osteoporosis later in life due to hormonal changes during menopause. The combined lack of calcium, vitamin D, and magnesium poses major risks to the development of adolescent bones and increasing the risk of osteoporosis and fractures in later life (Walsh *et al.*, 2024).

Copper is essential for growth, playing a key role in several enzyme systems, hemoglobin synthesis, the conversion of ferrous to ferric iron, and the production of transferrin through ceruloplasmin. Zinc, a critical cofactor for nearly 200 enzymes, supports cellular growth by aiding in RNA and DNA synthesis and is particularly important for gonadal development. During adolescence, zinc requirements are higher per kilogram of body weight than in adults because of its crucial role in growth and sexual maturation (Urbano *et al.*, 2002).

It's critical to have a strong immune system and general health throughout life, especially during adolescence. Adolescent are below recommended levels of several essential nutrients, such

as vitamins A, C, E, zinc, and potassium, which can lead to weakened immunity and increased vulnerability to illnesses(EFSA Panel on Ditetic Products, 2013) (Carr and Maggini, 2017).

2.7 Nutritional requirement of adolescents

Adolescence is a period of rapid growth and development, leading to increased nutritional requirements to support accelerated growth, sexual maturation, and changes in body composition. Energy and protein need rise to support muscle growth and organ development, while key micronutrients such as calcium, iron, zinc, and vitamin D are essential for bone mineralization, hemoglobin synthesis, and sexual maturation. These demands differ by sex, with girls requiring more iron due to menstruation and boys having greater energy needs for lean body mass. Inadequate intake during this stage can impair growth, delay puberty, and raise long term risks such as osteoporosis (Das *et al.*, 2017).

NIN (2020) has classified the period of adolescence into three groups of 10-12 years, 13-15 years and 16-18 years. Present guidelines of ICMR-NIN do not suggest an RDA for energy requirements although EAR for energy is suggested. There is no RDA for carbohydrates. But for visible fat it recommends the daily minimum intake levels and for total fats it recommends minimum amount of fat in terms of total calories. The recommendation of minimum daily total fat intake in adolescents is 25% of total calories. Fat from invisible source is recommended to be at least 10% of total energy. If the proportion of invisible fat increases, it is suggested to decrease the requirement of visible fat. The nutritional requirements of adolescents according to the ICMR 2020 are as follows:

Table 2.1: Nutritional requirements of adolescent, ICMR 2020

Nutrients	Gender					
	Boys			Girls		
	10-12	13-15	16-18	10-12	13-15	16-18
Energy	2200	2860	3320	2060	2400	2500
Protein *(g)*	32	45	55	33	43	46
Visible fats *(g)*	35	45	50	35	40	45
Calcium *(mg)*	850	1000	1000	850	1050	1050
Magnesium *(mg)*	240	345	440	250	340	380
Iron *(mg)*	16	22	26	26	30	32
Zinc *(mg)*	8.5	14.3	17.6	8.5	12.8	14.2
Thiamine *(mg)*	1.5	1.9	2.2	1.4	1.6	`1.7
Riboflavin *(mg)*	2.1	2.7	3.1	1.9	2.2	2.3
Vitamin B6 *(mg)*	2.0	2.6	3.0	1.9	2.2	2.3
Folate*(µg)*	220	285	340	225	245	270
Vitamin C *(mg)*	55	70	85	50	65	70
Vitamin B12*(µg)*	22	22	22	22	22	22

2.8 Nutritional assessment

Nutritional assessment can be defined as information interpreted from anthropometric, dietary, biochemical and clinical aspects (Gibson, 2005). These elements are utilized to detect nutritional issues of a chosen population in order to determine which group is at risk for chronic malnutrition and create successful nutritional intervention programs through surveys, surveillance, screening, and intervention.

In order to define goals, create, plan, monitor, and analyze programs aimed at ending hunger and lessening the impact of malnutrition in all of its manifestations, nutrition assessment offers timely, high-quality, and evidence-based information. In nutritional surveillance, research data is gathered, examined, and assessed using a standardized methodology over an extended period of time in order to identify potential nutritional risk factors for malnutrition, formulate policies for

the general public or a particular vulnerable group, or assess and track nutrition interventions (Gibson, 2025).

According to (Joshi, 2017) the assessment of nutritional status can be done by direct or indirect method as below:

a. Direct method: Addresses the individual and measure's objective criteria. The direct approach of nutritional surveys can be stated as ABCD.

i. Anthropometric method

ii. Biochemical assessment

iii. Clinical examination

iv. Dietary intake assessment

b. Indirect method: Use community indices to assess nutritional condition and need. The indirect approach of nutritional surveys can be stated as follows:

i. Vital health statistics

ii. Ecological factors

Direct method

a. Anthropometric assessment: Anthropometry has a long tradition of assessing nutritional and health status of adults as this is an inexpensive, non-invasive method that provides detailed information on different components of body structure, especially muscular and fat components (Bhattacharya *et al.*, 2019). It is employed to assess the child's overall health, nutritional sufficiency, and growth and developmental trajectory. The gold criteria by which doctors evaluate a child's health and wellbeing are growth measurements and typical growth trends. Body measures in adults can be used to evaluate nutritional status, future disease risk, and overall health. In order to diagnose obesity and identify underlying nutritional status, these measurements can also be used to assess an adult's body composition. Height, weight, head circumference, body mass index (BMI), body circumferences (waist, hip, and limbs) to measure adiposity, and skinfold thickness are the fundamental components of anthropometry(Casadei and Kiel, 2022).

Table 2.2: Anthropometric indicator cut-offs of nutritional status for adolescents

Z-score cut offs	Indicators	
	Height for Age	**BMI for Age**
Below -3 SD	Severely stunted	Severely thin
-3 SD to -2 SD	Moderately Stunted	Moderately thin
-2 SD to 1 SD	Normal	Normal
+1 SD to +2 SD	Normal	Overweight
+2 SD to +3 SD	Normal	Obese
Above +3 SD	Normal	Severely Obese

b. Biochemical and laboratory: Biochemical markers are very helpful in detecting early changes in nutritional status and body metabolism before clear clinical symptoms appear. Additionally, the results obtained are precise, accurate, and reproducible. The limitations include that these investigations are expensive and time-consuming, which makes them unsuitable for broad use (Shrivastava *et al.*, 2014).

c. Clinical examination: Since the main objective of nutritional surveys is to evaluate the health condition of individuals or groups within a population based on the type of food consumed, clinical assessment is a crucial component(Shrivastava *et al.*, 2014). According to (Suskind, 1998), clinical assessment involves a thorough physical examination alongside medical and dietary histories, with particular attention to growth patterns, pubertal development, and physical signs of malnutrition. An external assessment for changes in the superficial epithelial tissues, such as skin, eyes, hair, and buccal mucosa, can be carried out. Organs close to the skin's surface, such as the parotid and thyroid glands, may also be examined (Joshi, 2002).

d. Dietary evaluation: A thorough analysis of a person's food consumption is called a dietary assessment. It is the general phrase for all diet survey methods. Diet history, 24 hour dietary recall, food frequency questionnaire, record methods etc. are some of the common techniques used for dietary evaluation(Joshi, 2002)

Indirect method

a) Environmental factor: Poor economic conditions limit access to nutritious foods, while food-related myths and taboos often restrict consumption of important items, particularly among women. Cultural customs that cause nutrient deficiencies like vitamin D include women eating last or getting little sun exposure because of traditional attire. Religious restrictions on certain foods can further reduce protein and micronutrient intake. Additionally, early marriages and resulting early pregnancies negatively affect the health and nutritional status of young women (Upadhyay and Tripathi, 2017).

b) Vital health statistics: Vital data are gathered from several sources, including the community, medical experts, and monitoring networks. To assist the government in making policy decisions, all of the data gathered from various nations will provide a comprehensive picture of the nutritional status for that population of interest. For instance, determining the high-risk groups and estimating the disease's prevalence in the population can be accomplished by the study of morbidity and death statistics(Shrivastava *et al.*, 2014).

2.9 Dietary assessment

a) Food frequency questionnaire: The diet history approach is the foundation of FFQ. It keeps track of how often a person eats and drinks certain foods and drinks, either listed together (like green leafy vegetables) or separately (like lettuce), over an extended period of time, usually daily, weekly, monthly or yearly. The participant may complete the questionnaire directly or through an interviewer. Typically, the subject is asked to select the frequency of consumption from a list of pre-selected options(Naska *et al.*, 2017).

b) 24-hour recall: 24HR are fully open-ended questionnaires that gather a wide range of specific data regarding food intake over a given time frame. The 24HR takes 20 to 30 minutes to complete a single-day recollection and is conducted like an in-depth interview. Detailed data about food preparation methods, ingredients used in mixed dishes, and the brand name of commercial products may be required according to the research question. The amounts of each food consumed are estimated in reference to a common size container (e.g., bowls, cups, and glasses), standard measuring cups and spoons, a three-dimensional food model, or two-dimensional aids such as photographs (Shim *et al.*, 2014).

The list might be broad to allow for a thorough assessment of diet, or it could concentrate on particular nutrients, foods and food groups, or dietary exposures linked to particular illnesses

(Gurnovic *et al.*, 2017). Thus, the method assesses the actual intake of individuals. However, describing a person's typical dietary consumption of food and nutrients requires more than one 24-hour recollection. Multiple non-consecutive 24-hour recollections of the same person are necessary to capture daily variations in order to meet this goal(FAO, 2018).

c) Diet history: A dietary history is a thorough evaluation that details a person's typical food intake and how it has changed over a long period of time (six months to a year). Diet history consists of three parts:

• an in-depth interview to assess usual food intake and eating patterns.

• a food list

• a three-day record with portion size estimates used as cross-checks

A single interview can provide details on meal patterns, foods consumed, and usual intake, offering quantitative estimates of energy and nutrient consumption. This method is useful for assessing usual dietary intake overtime, estimating the prevalence of inadequate diets, capturing infrequently consumed foods, and does not require respondent literacy (FAO, 2018).

2.10 Dietary diversity

Dietary diversity (DD) is defined as the quantity of foods or food groups that a person consumes in a specific time period to ensure nutrient adequacy, diet variation, and diet quality. It is a qualitative indicator that measures the availability of a variety of foods in a home and food intake that shows how nutrient-dense a person's diet is. The dietary diversity questionnaire is an easy-to-use diagnostic tool that is rapid, easy to use, and reasonably priced. The data collected via the questionnaire is easy to score and analyze. Dietary diversity scores (DDS) are determined by adding up the quantity of foods or dietary groups consumed within a given time period (Kennedy *et al.*, 2011).

Individual dietary diversity (IDD) and household dietary diversity (HDD) are the two subcategories of dietary diversity.

a) **Household Dietary Diversity (HDD)**: It is the number of food types a person consumes the day before at home. This dietary diversity excludes food purchased and consumed outside the home and the person who prepares the food for the household on the previous day is considered responsible respondent. The purpose of the household dietary diversity score (HDDS) is to provide a quick overview of a household's financial capacity to purchase

a range of meals and correlates with the socio-economic status and household food security. The number of food groups included in this category is 12.

b) **Individual dietary diversity (IDD)**: It is the sum of the food groups that a person has ingested in the past 24 hours, whether at home or away from home. It provides insight into the nutritional adequacy of a person's diet. Everything that the person of interest eats, whether it is within or outside the home, regardless of where it was made, is included in IDDS.

The 10 predefined food groups, which underlie the validated MDD-W indicator (FAO, 2016), are as follows:

1. Grains, white roots, tubers, and plantains
2. Pulses (beans, peas, lentils)
3. Nuts and seeds
4. Dairy
5. Meat, fish, and poultry
6. Eggs
7. Dark green leafy vegetables
8. Vitamin A-rich fruits and vegetables
9. Other vegetables
10. Other fruits

2.11 Dietary Diversity and Nutritional Status

Food diversity has long been acknowledged as a crucial component of high-quality diets because no single food item can supply the proper number of nutrients required to maintain maximum health. Numerous historical examples support this notion, including the Imperial Japanese Army's high rate of beriberi, night blindness, and scurvy in the first half of the 20th century as a result of rice-based meals that contained few or no other foods (O Verger *et al.*, 2021).

It has been found that dietary diversity is highly correlated with the socioeconomic condition of the household. A cross-sectional study carried out in Matlab, Bangladesh showed that inadequate dietary diversity was significantly associated with Socio-economic status and household food security. When compared, Adolescents from the poorest households were

almost 1.6 times more likely to have inadequate DD than their peers from the wealthiest households. Adolescents from households experiencing food insecurity were 34% more likely to have inadequate DD than those from households experiencing food security, indicating a strong correlation between the two variables More nutrition-related issues were experienced by adolescents who resided in communities with low awareness and practice healthy eating. Furthermore, adolescents in developing nations do not receive adequate nutrients due to monotonous dietary dishes (Islam *et al.*, 2020).

Part III
Materials and methods

3.1 Research method

A cross-sectional study was conducted among the adolescents of 10-19 years age in three different selected schools of Itahari Sub-Metropolitan city.

3.2 Study location

Study was conducted in three different schools located at two wards of Itahari Sub-Metropolitan City.

3.3 Research variables

The difference variables of the study are shortly described as below:

3.3.1 Dependent variable

Anthropometric indices: Height for age, BMI for age

3.3.2 Independent variables

a) Socio-economic and demographic variables: Ethnicity, family size, number of siblings, number of adolescents in family, parent's occupation, family income, literacy of parents

b) Adolescents characteristics: Age, Sex, physical activity, sleeping hours

c) Dietary habit: Food habit related variables (vegetarian/non-vegetarian, skipping meals, fast food consumption etc.), nutrient intake, dietary diversity

d) Environmental condition: Source of water, purification of water

3.4 Target population

The target population were school going adolescents (10-19 years) of either sex.

3.5 Sample size calculation

The sample size is calculated by using single proportional statistical formula at 95% Confidence Interval (C.I), 7% marginal error and 5% non-response rate.

Sample size (n) = $z^2 \times p(1-p)/d^2$

where, z =confidence interval at 95 %

P= estimated prevalence of malnutrition

d = margin of error

Here, p is estimated on the basis of the research conducted by (Kafle et al., 2020) in school going adolescents of Eastern Nepal. The result obtained from this study showed that 47.3% of students were found to be underweight. Thus, 47.3% is taken as the estimated prevalence of malnutrition (p) for the calculation of sample size for this research study.

$$n0 = \frac{(1.962)^2 \times 0.473 \times (1 - 0.473)}{(0.072)^2} = 195.4 \approx 195$$

With addition of non-response rate of 5%, sample size becomes,

195+9.5=204.7 ≈ 205

3.6 Sampling

A cross-sectional descriptive study was conducted in Itahari Sub-Metropolitan city. Participants were selected through a multistage random sampling method out of 20 wards. From each ward, one school was selected randomly using a simple random sampling method (lottery method) from the list of all schools available in each ward, resulting in a total of 3 schools for inclusion in the study. The list included private schools with adolescents aged 10-19. Random selection was likewise performed for the inclusion of students from each school attending 5^{th} to 10^{th} grade to ensure heterogeneity in ages of student.

3.7 Criteria for sample selection

Inclusion criteria

The participants with following criteria were included in study

- Must be adolescent (10 to 19 years).
- The students whose permanent residence was Itahari Sub-Metropolitan
- Students who willingly signed consent forms.

Exclusion criteria

The population with any one of the following characters was excluded from the study:

- Students whose permanent residence were out of Itahari Sub-Metropolitan city.
- Students who were ill and physically disable.

3.8 Research instruments

The following instruments were used for the research work:

a) Stadiometer: A well calibrated stadiometer, measuring up to 200 cm with least count of 0.1 cm, to assess the height of participants.

b) Digital weighing balance: A digital weighing balance, measuring up to 180 kg with least count of 0.1 kg.

c) Questionnaire: Well designed and pretested set of questionnaires to collect information on demographic variables, socio-economic condition, dietary practices and related habits, environmental conditions of the targeted participants

d) Dietary diversity score and 24-hour dietary recall data sheet. A well-designed dietary diversity score table derived from WHO/FAO guidelines along with 24-hour recall sheet to study the food consumption pattern and nutrient intake of the adolescents under study.

e) Standardized utensils

3.9 Data entry and analysis

The anthropometric data was entered into WHO Anthro-plus for analysis, while the statistical data was entered into IBM Statistical Package for Social Science (SPSS) version 20.0 and Microsoft Excel 2019. The software mentioned earlier was used to analyze the gathered data using both descriptive and inferential statistics. Chi- square test was used to determine relationship between nutritional status and its associated factors. The nutritional status was measured with reference to WHO Standards and anthropometric indices classified according to standard deviation units (z-scores), based on the WHO criteria. The nutrient intake was calculated using the food composition table from DFTQC and was compared to RDA given by ICMR-NIN 2020 for adolescents.

3.10 Pretesting

A selected number of adolescents participated in a pretest of the created questionnaire and instrument. Pre-testing was performed to ensure that the questions were clear and accurate, to make sure that the questions were interpreted consistently, and to detect any confused items.

All recommended changes were implemented after the instruments were reviewed and then employed during the actual trial.

3.11 Validity and reliability of the research

The instruments were verified in order to determine the extent to which the data collection tools measure what they are intended to measure. The validity of the weighing balance was determined by comparing the data from our weighing balance to standard weights. validity of stadiometer was determined by comparing the measurement from our stadiometer with those from UNICEF's. A thorough analysis was conducted prior to data collection to determine whether the research tools and questionnaires aligned with the study's goals. To ensure validity, the questionnaire was also pre-tested before data collection. As previously stated, the questionnaire and the dietary diversity score questionnaire were reviewed every day for accuracy, consistency, and completeness.

3.12 Data collection techniques

Anthropometric measurements and a semi-structured questionnaire were used for collecting primary data. The adolescents were interviewed in order to collect sociodemographic data and complete the questionnaire.

Height and weight were measured by using stadiometer and digital weighing balance as below:

1. Height: Height was measured using stadiometer. The measuring device was checked for accuracy using standard 2-m steel tape. In order to measure the height, the participant was first instructed to stand upright, barefoot, with their heels together and their arms hanging loosely on a horizontal platform. The head was made on a Frankfurt plane with the shoulder blades and buttocks touching the stadiometer's vertical surface. The participant was instructed to stand tall and take deep breaths to let his/her shoulders relax and his spine straighten. Movable headboard was lowered until it touches crown of head. To prevent parallax mistakes, the examiner's eyes were level with the headboard when the height was measured at maximum inspiration. The measurement was made to the closest 0.1 cm. A lower reading was noted for readings that were between two values (Oppizzi, 2004).

2. Weight: Measurement were made after the bladder was emptied and had minimal clothing. The scale was set to zero and the balance was set up on a hard surface level. The subject was instructed to stand unsupported in the middle of the platform, looking straight ahead while remaining calm and still. Weight was measured to the closest 0.1 kg (Eaton-Evans, 2013)

3. Dietary recall: Dietary intake data was collected using the 24-hour recall method. As part of the 24-hour recall, participants were asked to list every food and beverage they had consumed throughout the preceding day, from their first meal of the day until their last meal before bed. Every participant was encouraged to recall everything they had eaten and drunk during the previous 24 hours. We were able to acquire information about forgotten foods by probing (Weerasekara *et al.*, 2020).

4. Dietary diversity: The Dietary diversity score in this study was calculated based on WHO/FAO recommended food groups that reflect nutrient adequacy. Dietary diversity score in this study was calculated using data from the 24-hour dietary recall section of the questionnaire. The recall captured all foods and beverages consumed by the adolescents the previous day, categorized into 10 standard food groups based on FAO guidelines (Kennedy *et al.*, 2011). In the dietary diversity scoring section of the questionnaire, each listed food group was assigned a binary score:

"1" if the adolescent consumed any food item from that group in the previous 24 hours

"0" if not

The final DDS was calculated by summing the 1s with the maximum possible score of 10.

3.13 Ethical consideration

Study was conducted after getting approval letter from the municipality office. Following an explanation of the objective of the research, the principal of the school gave consent to administer the survey, and the respondents likewise gave their approval. Assurance about confidentiality of the collected data was given to the respondents that no information received from the study will be given or disclosed to unauthorized people external to the team implementing the study.

Part IV
Results and Discussion

A cross-sectional study was carried out to assess the dietary diversity and its association with nutritional status of adolescents residing in Itahari Sub-Metropolitan city. The study was conducted by assessing height and weight and a semi-structured questionnaire was used to explore the demographic, socio-economic and environmental factors. The dietary intake and dietary diversity were assessed through 24-hour diet recall.

5.1 Adolescents' characteristics

Table 4.1 displays the gender specific frequency distribution of the population under study i.e. adolescents. The study sample included approximately 205 participants in the study, with a comparatively greater proportion of males 51.2% than females 48.8%. According to the National Population and Housing Census 2021, the male population percentage of Itahai Sun-Metropolitan City is 47.3% and that of female 52.7%.

Table 5.1: Percentage and frequency distribution of gender of adolescents (n=205)

Gender	Frequency	Percentages (%)
Male	105	51.2
Female	100	48.8
Total	205	100

The age distribution in table 4.2 shows that the majority of adolescents (56%) belonged to the 10-14 age group, while (43.9%) were in the 15-19 age group. This suggests a greater representation of early adolescents in the sample.

Table 5.2: Percentage distribution of age group of study population (n=205)

Age	Male	Female	Total
10-14	31 (15.5%)	52 (26%)	83 (41.5%)
15-19	62 (31%)	55 (27.5%)	117 (58.5%)
Total	93 (46.5%)	107 (53.5%)	200 (100%)

Note: values in the paratheses indicates percentage

Among the 205 households included in the study, more than half (69.3%) had one adolescent member, followed by families having 26.8% with two adolescents, 3.9% with 3 and above adolescents. The majority of the participants, i.e., 47.3%, had only one sibling; 26.8% had two siblings, followed by 3.9% who had three or more siblings and 22% of participant had no siblings within the family. The participant's birth order was highest, with 57.1% being the eldest in the family, whereas the percentage for the second and third children were 19.5% and1.5% respectively, followed by 22% of them being fourth or above fourth. The adolescent characteristics are shown in Table 4.3 below:

Table 5.3 Frequency distribution of adolescent characteristics (n=205)

Variables	Frequency	Percentage (%)
No. of adolescents in family		
1	142	69
2	55	26.8
3 and above	8	3.9
Birth order of the adolescent		
1	117	57.1
2	40	19.5
3	3	1.5
4 and above	45	22.0

5.2 Demographic characteristics

As displayed in table 4.4 of the 205 survey respondents, the majority of respondents belonged to janajati ethnic group i.e. 32.2% mostly containing Rai, Limbu, Tamang, Magar and Newar people. Chettri made up 29.8% of the population, followed by Brahmins (24.4%), Madhesi (11.2%) and Dalits (2.4%), who made the least percentage. Of the total number of religions practiced, 81% were Hindu, 10.7% were Kiranti, 4.9% were Buddhist, and 2%.4 were Christian. Out of the 205 participants, 88 (42.6%) lived in nuclear households and 116 (56.6%) in extended families. Likewise, 87 (42.4%) adolescents belonged to households with sizes below the national average, while 57.5 % belonged to families with sizes above the national average household size. According to National Population and Housing Census 2021, the national average household size is 4.37.

Table 5.4 Frequency distribution of demographic characteristics of adolescents (n=205)

Variables	Frequency	Percentage (%)
Ethnicity		
Brahmin	50	24.4
Chhetri	61	29.8
Janajati	66	32.2
Dalit	5	2.4
Madhesi	23	11.2
Religion		
Hindu	166	81.0
Christian	5	2.43
Buddhist	10	4.9
Kirati	22	10.7
Family type		
Nuclear	88	42.9
Extended/Joint	116	56.6
Family size		
Below average family size	87	42.4
Above average family size	118	57.5

5.3 Social-economic characteristics

The given data in table no 4.5 reveals that the majority of adolescents father had attained at least secondary level education, with 48.8% completing secondary education and 32.2% having higher secondary education or above. Only a small proportion of fathers were illiterate (6.3%), while 12.7% had completed only primary or informal education. In comparison, mothers'

education levels were slightly lower. Although nearly half (49.8%) of the mothers had completed secondary education, only 25.9% had pursed higher secondary education or above. A notable 19.5% had only primary or informal education, and 4.9% were illiterate.

Table 5.5 Frequency distribution of education level of parents (n=205)

Variables	Frequency	Percentage
Education of father		
Higher Secondary or above	66	32.2
Secondary	100	48.8
Primary/ Informal	26	12.7
Illiterate	13	6.3
Education of mothers		
Higher Secondary or above	53	25.9
Secondary	102	49.8
Primary/Informal	40	19.5
Illiterate	10	4.9

Table 4.6 shows the economic characteristics of adolescents. The majority of households (85.4%) reported a monthly income of NPR 30,000 or more. Only 14.6% of households fell below the income threshold. The occupational profile of fathers was relatively diverse, with the majority involved in business (31.7%), followed by foreign employment (27.8%), and service (22.0%). Only 8.3% were engaged in agriculture, and 10.3% worked as laborers or other miscellaneous occupations that include daily wage work and other forms of employment like driving, carpentry, masons, etc. A large majority of the mothers (75.6%) were housewives,

followed by small proportions in business (10.2%), foreign employment (6.98%), and service (4.9%). Very few were involved in agriculture (2%).

Table 5.6 Frequency distribution of economic characteristics of adolescent (n=205**)**

Variable	Frequency	Percentage
Family income (monthly)		
More than or equal to 30000	175	85.4
Less than 30000	30	14.6
Occupation of father		
Agriculture	17	8.3
Service	45	22.0
Business	65	31.7
Foreign employment	57	27.8
Labor and Others	21	10.3
Occupation of mother		
Housewife	155	75.6
Agriculture	4	2
Service	10	4.9
Business	21	10.2
Foreign employment	14	6.8

5.4 Environmental condition

A significant number of studied populations were using purified water (75%) while 24.9% of them were using unpurified water with 95.6 % using tap water as source of drinking water provided by the municipality. All the families were equipped with toilet facilities. The frequency distribution of the following environmental parameters is displayed in Table 4.7.

Table 5.7 Frequency distribution of environmental characteristics of adolescent (n=205)

Variables	Frequency	Percentage
Source of drinking water		
Tap water	196	95.6
Well/River	9	4.4
Purification of water		
Yes	154	75.1
No	51	24.9

5.5 Dietary habits

Table 4.8 shows the dietary habits of the adolescents. Among the respondents a vast majority (83.4%) followed a non-vegetarian diet, while only 16.6% identified as vegetarian. When asked about the meal skip 64.4% of adolescents reported skipping meals, a behavior with significant nutritional and metabolic implication. Among the adolescents who reported skipping meals (n=132), the most commonly skipped meal was breakfast (42%), followed by snacks (10.7%), lunch (7.3%), and dinner (4.4%). The primary reason cited for meal skipping was lack of time (30.2%), followed by poor appetite (17.6%), weight loss attempts (8.3%), and health consciousness (8.3%). More than half of the adolescents (62.9%) received pocket money regularly, while (37.1) did not receive any pocket money. A high percentage of adolescents (66.3) bought food from shops or vendors. Only (33.7) did not purchase food from these sources. The foods that were frequently bought by adolescents were chatpate, noodels (wai-

wai, rumpum), chips, biscuits, chocolates, momo, chowmein, samosa etc. The school canteen was the primary source of tiffin for (60%) adolescents. A majority (60%) obtained their tiffin from the school canteen, while only 37.1% brought home prepared meals. About 35.1% of adolescents reported watching TV or using phones during meals, while majority (64.9%) did not. The majority of the females (93%) were taking the iron folic acid tablet provided by the School Health and Nutrition program of the government, which was provided by the school during the program month. A small percentage (7%) were not taking IFA tablets.

According an analytical cross-sectional survey conducted by (Abdulai *et al.*, 2023) among adolescent in Tamale metropolis, Ghana also showed that, almost 87.8% of the respondents skipped meal and the most commonly skipped meal was breakfast (66.3%), with lack of appetite (27.3%) and lack of time (21.3%) being the main reason which is consistent with the study's findings that the majority of teens mentioned a lack of time as the main reason for missing meals.

Table 5.8 Frequency distribution of dietary habits and behavior of adolescents (n=205)

Variables	Frequency	Percentage
Veg/non-veg eating behavior		
Veg	34	16.6
Non-veg	171	83.4
Skip meal		
Yes	132	64.4
No	73	35.6
Type of meal skipped (n=132)		
Breakfast	86	42
Lunch	15	7.3
Dinner	9	4.4
Snacks	22	10.7
Reason for meal skipping		
Weight loss	17	8.3

Poor appetite	36	17.6
Health conscious	17	8.3
No time for meal	62	30.2
Pocket money		
Yes	129	62.9
No	76	37.1
Buy food from shop/vendor		
Yes	136	66.3
No	69	33.7
Take tiffin from		
School canteen	129	60.0
Home based	76	37.1
Watch tv/browse phone during meals		
Yes	72	35.1
No	133	64.9
IFA tablet by girls(n=100)		
Yes	93	93
No	7	7

5.6 Dietary intake in preceding day

Table 4.9 shows the adequacy of the nutrients intake by adolescents calculated using 24hour diet recall. The DFTQC food composition table was used for the nutrient calculation, and then it was compared with the RDA given by ICMR-NIN for the adequacy of macronutrients. The analysis of nutrient intake among adolescents revealed that a significant majority (73.7%) had inadequate energy intake, with only 26.3% meeting the recommended energy requirements. In terms of protein intake, more than half of the adolescents (58.5%) succeeded in meeting adequate levels, while 41.5% were found to have insufficient protein intake. Regarding fat

intake, the inadequacy was even more pronounced. A vast majority (73.7%) of adolescents did not meet the required fat intake levels, and only 26.3% were found to have adequate fat consumption. Overall, the data indicates that a large proportion of adolescents had suboptimal intake of key macronutrients, which may have implications for their nutritional status, growth, and overall health outcomes.

Table 5.9 Frequency distribution of macronutrients adequacy of adolescents (n=205)

Nutrients intake	Frequency	Percentage
Energy		
Inadequate	151	73.7
Adequate	54	26.3
Protein		
Adequate	120	58.5
Inadequate	85	41.5
Fat		
Adequate	54	26.3
Inadequate	151	73.7

5.7 Mean nutrient intake

The table below summarizes the average intake and variability in energy, carbohydrates, protein, and fat consumption for male and female separately among three age groups categorized by ICMR and compared with the respective Recommended Dietary Allowance (RDA). Among the adolescent boys aged 10-12 the mean energy intake was 1977 kcal with the standard deviation of 464.41, which was approximately 89.9% of RDA. The mean protein intake was 39.25±10.89g, which met 122.7% and was 1.2 times more than the RDA indicating adequacy. The total fat intake was 33.34 ± 7.34 g, covering 95.2% of recommendations, while the carbohydrate intake was

293.94 ± 60.83 g. For boys aged 13-15 years, the mean energy intake was 2311.14 ± 501.79 Kcal, which met 92.4% of the RDA. Protein intake was 49.22 ± 12.14 g, which was 1.1 times greater than the recommended levels of 45g. Fat intake was 37.12 ± 6.51g, making up 82.5% and carbohydrate intake was 354.74 ± 97.74g. Among boys aged 16-18 years, the average energy intake was 1932.2 ± 240.9 Kcal, which was only 69% of the total requirements. The mean protein intake was 58.06 ± 14.15g, which was 1.05 times higher than recommended, suggesting adequacy. The total fat and carbohydrate intake was 49.82 ± 10.52 g and 297.08 ± 40.70g respectively.

The mean nutrient intake among adolescent females was assessed, for girls aged 10-12 years, the mean energy intake was 1760.9 ± 349.2 Kcal, which was 89.4% of the RDA. The average protein intake was 38.0 ± 6.77g, which was 1.15 times higher than the recommended level. Meanwhile, the fat intake was 30.3 ± 3.84g, about 86.7% of the RDA. Among the 13-15 years old girl, the mean energy intake was 1941.9 ± 353.9 Kcal, covering 94.3% of the RDA. The average protein intake was 40.4 ± 7.77g, which was slightly below the RDA about 93.9%, while fat intake was 34.6 ± 8.14g, 86.4% of the RDA. The mean energy intake of the 16-18 years aged girls was 2084±559.55 Kcal which was 83.36% of the required intake. The protein intake was 41.96±10.02g, which was 93.24% of recommended. The fat and carbohydrate intake were 40.34±10.06g and 297.96±91.78g respectively.

From the analysis of mean nutrient intake, it is revealed that while the majority of adolescents met or exceeded recommended intake of protein, their energy and fat intakes were generally below the RDA across all age groups. Boys consistently consumed more energy and protein compared to girls; however, both sexes showed suboptimal fat intake. Carbohydrate intake was adequate for all ages and gender as minimum intake is 130g/day according to ICMR.

Table 5.10 Mean nutrients intake (n=205)

Age Group	Gender	Energy (kcal)	Protein (g)	Total Fat (g)	Carbohydrates (g)
10-12 years	Male	1977 ± 464.41	39.25± 10.89	33.34 ± 7.34	293.94 ± 60.83
	Female	1760± 349.2	38 ± 6.77	30.33± 3.84	259.63 ± 45.99
13-15 years	Male	2311.14 ± 501.79	49.2± 12.14	37.12± 6.5	354.73 ± 97.74
	Female	1941.9± 353.9	40.36 ± 7.77	34.57 ± 8.13	292.81 ± 52.3
16-18 years	Male	2703.98 ± 688.86	56.33 ± 11.87	40.99 ± 9.28	469.86 ± 148.82
	female	2084 ± 559.55	41.96 ±10.02	40.34 ±10.06	297.96 ± 91.78

5.8 Dietary Diversity Score

The mean dietary diversity score (DDS) was found to be 3.9 with standard deviation of 0.94. Low dietary diversity was indicated by the vast percentage of adolescents, accounting for 72.7% of the sample. Just 27.3% of respondents attained the minimal dietary diversity score with a score of 5 or higher.

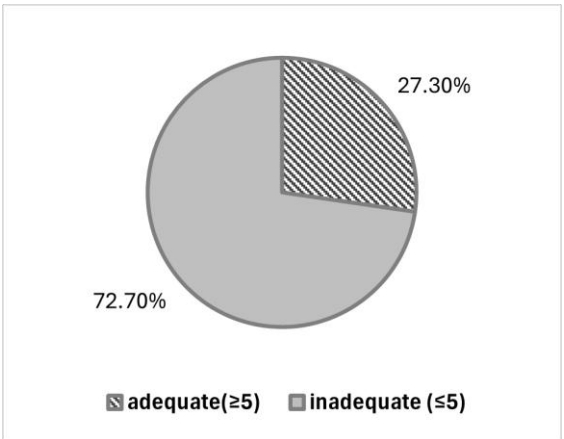


Figure 5.1 Frequency distribution of IDDS of studied adolescents (n=205)

The table 4.11 below shows that average dietary diversity score was 3.9, with a standard deviation of 0.94. Out of 10 food groups, the adolescents consumed a minimum of 3 and a maximum of 7 food groups.

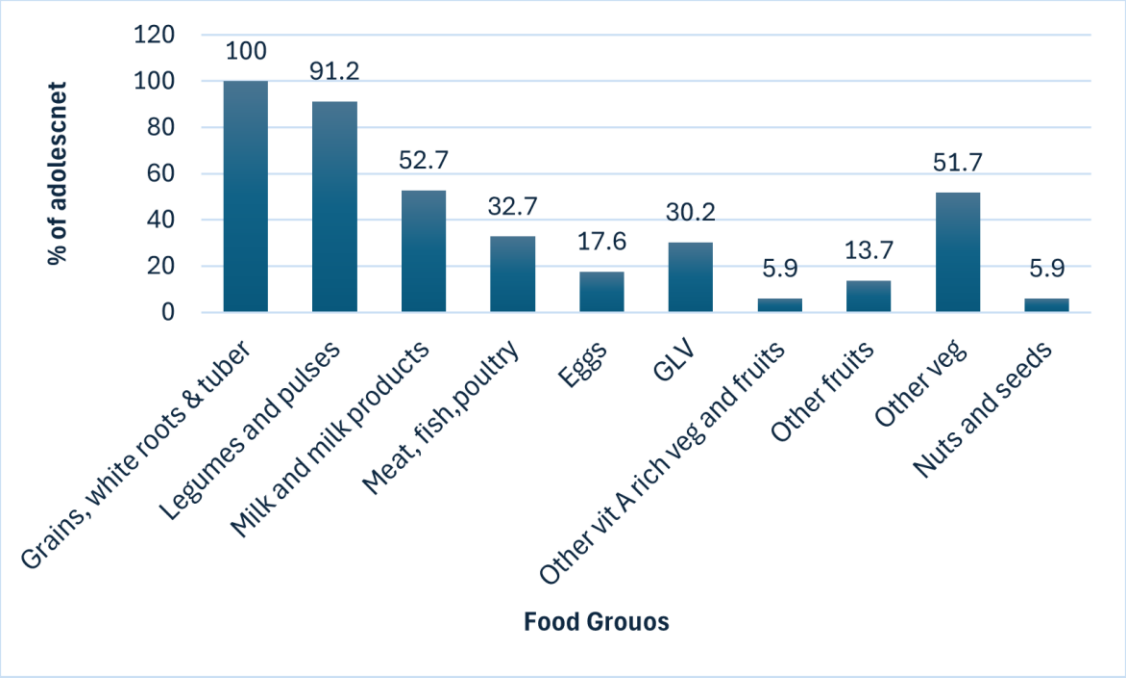
Table 5.11 Average and dispersion and DDS of adolescents (n=205)

	Minimum	**Maximum**	**Mean ± S.D**
DDS	3	7	3.9 ± 0.94

Based on a study carried out in Nepal (Manandhar and Kakchapati, 2023), only 27.3% of teenagers had a diet that was sufficiently diverse, while more than 70% of the adolescent fail to consume the wide variety of foods necessary to maintain a healthy life, aligning closely with our result. Similarly, research conducted in rural Ghana by (Wiafe *et al.*, 2023)reported a mean dietary diversity score was 3.8±0.8, with approximately 84.7% of participants exhibiting inadequate dietary diversity. Likewise, a study done in Gurage zone, Southwest Ethiopia, by (Worku *et al.*, 2017) found that only 26.8% of adolescents met the recommended dietary diversity score whereas, 73.2% had inadequate dietary diversity. These findings are consistent with our study.

The figure illustrates the proportion of adolescents consuming each of the ten food groups used to calculate dietary diversity score. Nearly all participants consumed grains, roots, and tubers (100%) and legumes and pulses (91.2%), indicating a cereal and pulse-based diet. Moderate consumption was observed for milk and milk products (52.7%) and other vegetables (51.7%), while intake of meat, fish, and poultry (32.7%) and dark leafy vegetables (30.2%) was relatively low. Notably, the consumption of eggs (17.6%), fruits (13.7%), Vitamin A rich fruits and vegetables (5.9%) was very limited. These findings suggest that while staple foods were widely consumed, the diets of adolescents lacked diversity in rich micronutrient foods and animal source foods, which may compromise overall nutrient adequacy.

Figure 5.2 Proportion of adolescent who consumed different food groups during the 24-hour recall period (n=205)



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The pattern observed in present study, almost universal consumption of staple foods (grains, roots/tubers), moderately high legumes/vegetables use, but very low intake of eggs, dairy, vit A rich fruits/vegetables, and other micronutrient dense foods is consistent with national findings from Nepal. According to the 2016 Nepal Demographic and Health survey, over 92% of children consumed staples, while only 70% consumed legumes and nuts, and intake of eggs, flesh foods, and dairy was much lower. Although these figures are from children, they reflect household food diversity and likely mirror the dietary patterns of adolescent as well, who share the same food

environment and suggest that adolescents in Nepal are similarly reliant on starchy staples, with limited consumption of nutrient-dense food groups.

Comparable results have been reported elsewhere; for instance, in Uganda, nearly all adolescent consumed cereals/roots/tubers, but only 11% consumed eggs and 8% consumed other fruits (Isabirye *et al.*, 2020). Likewise, in Ethiopia, cereals, legumes, and vegetables were common, but intake of animal source foods, milk and vitamin A rich foods was limited. These findings collectively highlight a widespread dependence on staples and legumes across low-income settings, with poor dietary diversity in animal-source and micronutrient-rich foods (Endalifer *et al.*, 2021).

5.9 Knowledge of nutrition

In accordance with table 4.12, a greater proportion of adolescents (62.9%) had adequate knowledge of nutrition, whereas 37.1% had inadequate.

According to the school based cross-sectional study carried out among adolescent girls by (Melaku *et al.*, 2017) showed girls exhibited strong nutritional awareness, accounting for 55.8% of the sample, whereas 44.2% had inadequate nutritional knowledge,

Table 5.12 Frequency distribution of nutrition knowledge (n=205)

Nutritional knowledge	Frequency	Percentage
Inadequate	76	37.1
Adequate	129	62.9

5.10 Prevalence of malnutrition

Figure illustrates the prevalence of stunting, thinness, and obesity among male, female, and overall adolescents. The overall prevalence of stunting was found to be 16.1%, with a slightly higher rate among females (8.8%) than males (7.3%). Similarly, thinness affected 14.1% of the total adolescents, with males (7.8%) experiencing a marginally higher prevalence than females (6.3%). In contrast, the prevalence of obesity was relatively lower across all groups, with 2.4% observed in both males and females, and a combined a overall prevalence of 4.8%.

Figure 5.3 Prevalence of malnutrition in adolescents (n=205)

Although Nepal lacks national data on the nutritional status of actual adolescents (10–19), NDHS 2022 provides information on the nutritional status of late adolescents (15–19). The data shows that 41% of male and 26% of female are thin, whereas 7% of male and 6% of female are overweight or obese. Based on data from the Global School-Based Student Health Survey in Asia, the overall prevalence of stunting in South Asia was 13%, thinness was 10.8%, and overweight was 10.8%. A significant percentage of South Asian adolescents studying in school were overweight, thin, and stunted, suggesting that this population suffers from the double burden of malnutrition (Estecha Querol *et al.*, 2021), which is also evident from our study's results, which showed that both undernutrition and overnutrition were common.

In comparison to this study, research conducted among school going adolescent in Solukhumbu, Nepal, by (Sherpa *et al.*, 2019) recorded that 27.6% of adolescent were underweight, while 5.7% being overweight and 1.6% being obese. Similarly, a cross- sectional analytical study carried out in Gokarneshwor municipality of Nepal by (Chaulagain, 2020) found that 17.2% of school adolescent aged 10-19 years were found stunted, including 14.7% moderately stunted and 2.51% being severely stunted findings that are higher comparable to those of our study. The

prevalence of obesity in our study aligns with results from a study conducted in Nagarjun municipality, Nepal, (Gautam *et al.*, 2024) which reported a prevalence less than 10% specifically 6.38%, slightly higher by 1.58 % as observed in our findings. Furthermore, a study conducted in Zanzibar Island, Tanzania, revealed a higher prevalence of thinness among adolescent boys (10.2%) compared to girls (4.8%) (killel *et al.*, 2025)which supports our findings as boys (7.8%), as opposed to girls (6.3%), were thinner.

5.11 Age group wise distribution of malnutrition

Table 4.13 illustrates the nutritional status of adolescents stratified into two age groups: early adolescents (10-14) and late adolescents (15-19) years, assessed based on height-for-age (HAZ) for stunting and BMI-for-age (BAZ) for thinness and overweight/obesity. In terms of stunting, a higher prevalence was observed among early adolescents aged 10-14 years, with 11.7% classified as stunted, compared to 4.3% in the 15-19 years group.

Table 5.13 Age group-wise distribution of malnutrition (n=205)

Age group	**10-14 yrs**	**15-19 yrs**
Stunting		
Normal	91(44.3%)	81 (39.5%)
Stunted	24 (11.7%)	9 (4.3%)
Thinness/obesity		
Normal	100(48.8%)	66 (32.2%)
Thinness	13 (6.3%)	16 (7.8%)
Obesity/overweight	2 (1.0%)	8 (3.9%)

Note: value in the paratheses indicate percentage

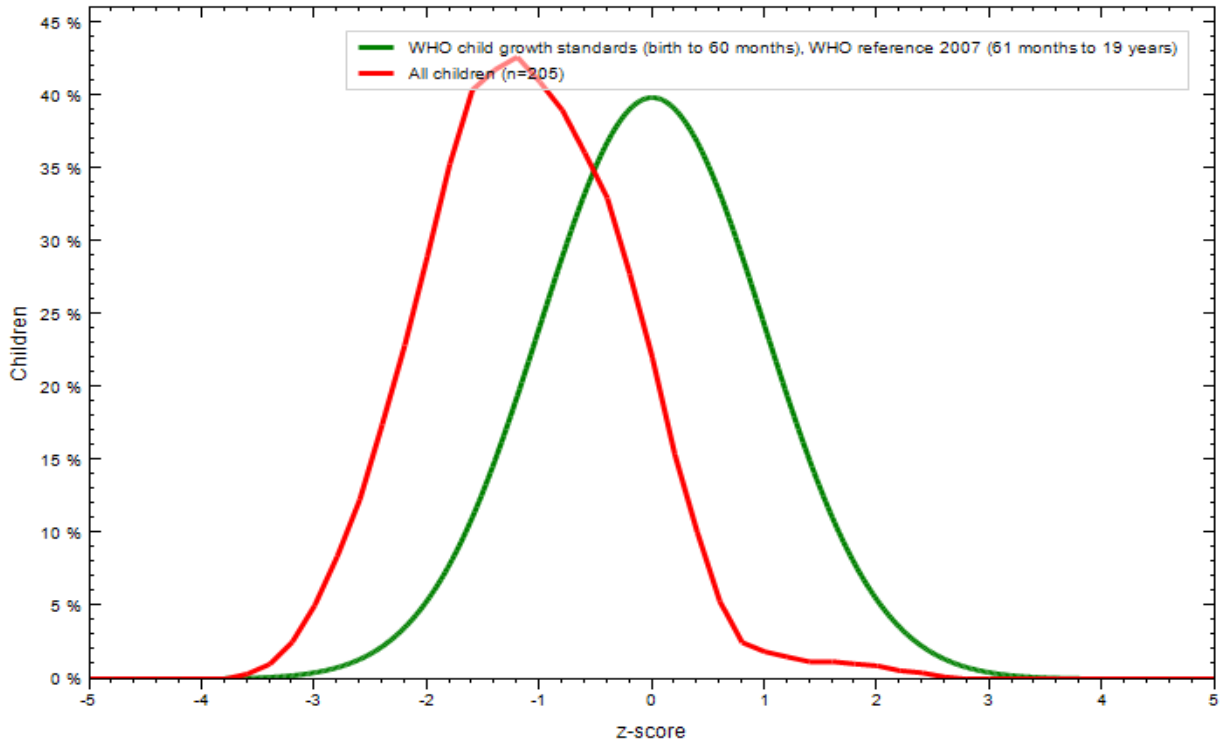
Regarding thinness and overweight/obesity, 6.3% of adolescents aged 10-14 years were identified as thin and 1.0% as overweight or obese. In contrast, among adolescents aged 15-19 years, both the prevalence of thinness (7.8%) and obesity (3.9%) showed an upward trend in older age group as compared to early adolescents.

(B.K *et al.*, 2025) also reported that the adolescent aged 15-19 years exhibited a significantly higher prevalence of underweight at 20% compared to younger adolescent 10-14 years at 4.1%. Similarly, a cross-sectional research performed in Gosaikunda, Rasuwa district by (Sitaula *et al.*, 2023) found that adolescent of 15-17 years of age had significantly higher prevalence of overweight/obesity (68.2%) than age groups of 11-14 years, i.e. 24.7%.

5.12 Comparison of nutritional status z-scores with WHO standards

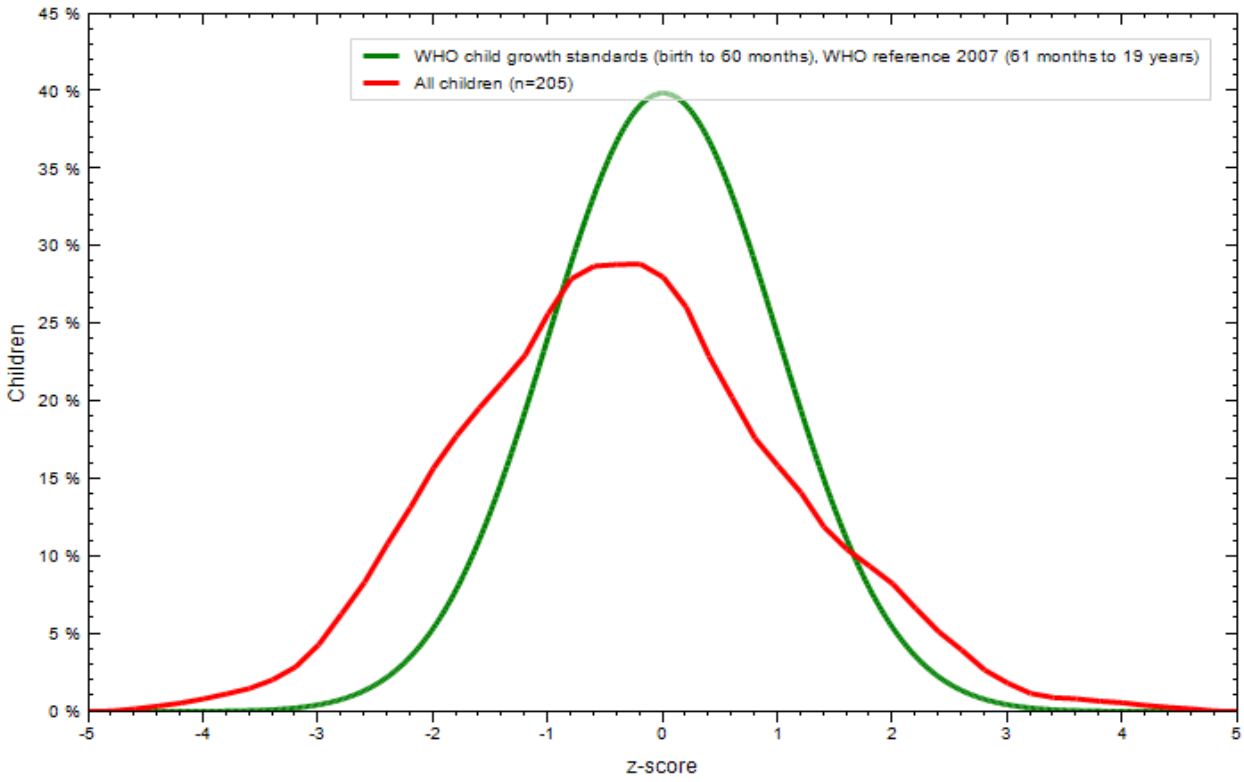
Figure 4.2 shows the comparison between the height for age of the study population with that of the WHO standards. The graph representing the population studied illustrates a leftward shift compared to WHO reference curve as the mean z-score for the height-for-age of study population is -1.1177±0.877 which is less than that of WHO standards i.e. 0. The median and mode are -1.1600 and -1.92 respectively. As illustrated, our peak of data is higher as compared to normal curve, with the majority of the values concentrated around the sample mean and are lesser than the WHO mean. The negatively skewed distribution of studied population displays that a considerable number of participants fall below the z-score threshold indicating a substantial proportion of adolescents experiencing stunting.

Figure 5.4 Graph of the normal distribution of height-for-age in studied children (n=205)



The graph representing the population studied depicts to be broader and slightly flatter than the reference curve (WHO standards), suggesting a greater dispersion of BMI values within the adolescents surveyed. The distribution is symmetric, and descriptive statistics support this visual pattern, the mean, median and mode being -0.35±1.35, -0.3500 and -0.21 respectively. The data's distribution on either side of the median reflects the emerging double burden of malnutrition, where both undernutrition (thinness) and overnutrition (obesity) coexist within the same population.

Figure 5.5 Graph of normal distribution for BMI-for-age z-score (n=205)



5.13 Dietary diversity association with overweight/obesity and thinness

In the present study, dietary diversity was significantly associated with nutritional status (p value=0.029).

Table 5.14 Dietary diversity association with thinness and overweight/obesity (n=205)

Factors		Normal	Thinness	Obesity	χ2 - value	p-value (<0.05)
DDS	Adequate	51 (24.9%)	2 (1.0%)	3 (1.5%)	7.097	*0.016 f
	Inadequate	115 (56.1%)	27 (13.2%)	7 (3.4%)		

Note:'f' symbol denotes values of Fisher's exact test or Fisher-Freeman-Halton extension

In the present study, a higher proportion of adolescents with inadequate dietary diversity were found to have normal BMI-for-age compared to those with adequate dietary diversity. Adolescents with inadequate DDS (<5 food groups) were more likely to be thin and in some cases obese alongside normal nutritional status. This pattern suggests that inadequate dietary diversity contributes to both undernutrition and overnutrition among adolescents. Limited consumption of diverse foods can lead to deficiencies in essential nutrients, predisposing individuals to thinness and impaired growth. Conversely, adolescents with low diverse monotonous diets dominated by energy dense but nutrient poor foods experience excess calorie intake, increasing the risk of being overweight and obese. This finding is somewhat consistent with a study conducted among Bangladeshi adolescents, here adolescents consuming three or fewer food groups the majority (58.33%) had a normal weight, 8.33% were underweight and 16.67% were either overweight or obese, while those consuming seven or more food groups showed higher proportion of normal weight and a lower (11.67%) prevalence of overweight and obesity (Akter *et al.*, 2025). However, the study also noted that the association between dietary diversity and nutritional status did not retained in multivariate analysis which suggests that while dietary variety plays an important role, its influence may be mediated by other factors like household food security and age. Even though the categorization of dietary diversity differed between studies, both studies reinforce that greater dietary diversity is protective against undernutrition.

In the present study, adolescents with inadequate dietary diversity showed a higher prevalence of overweight and obesity. Similar findings were reported among adolescent girls in West Sumatra

those with lower DDS, 83.3% (Susmiati, 2024). This suggests that the higher obesity observed in adolescents with less diverse diets may be explained by excess energy consumption, particularly from energy-dense foods, rather than dietary diversity per se.

5.14 Dietary diversity association with stunting

Table 5.15 Dietary diversity association with stunting (n=205)

Factors		**Normal**	**Stunted**	**χ2 –value**	**p-value (<0.05)**
DDS	Adequate	47 (22.9%)	9 (4.4%)	0.000	0.995
	Inadequate	125 (61%)	24 (11.7%)		

In this study the chi-square test confirmed no significant association between dietary diversity and stunting (χ^2=0.000, p=0.995).

In a systemic review and metanalysis on association of dietary diversity with undernutrition in school aged children found participants with inadequate dietary diversity had 43% higher estimated odds of stunting compared to those with adequate diet diversity (Zeinalabedini *et al.*, 2023).

5.15 Factors associated with malnutrition

5.16 Factors associated with stunting

The present study explored the association between selected socio-demographic and dietary factors with stunting among adolescents. Findings revealed that age group, energy adequacy, protein adequacy, and fat adequacy were significantly associated with stunting ($p<0.05$).

Table 5.16 Factors associated with stunting (n=205)

Factors		**Normal**	**Stunted**	**χ2 –value**	**p-value (<0.05)**
Age group	10-14	91 (44.4%)	24 (11.7%)	4.416	*0.036
	15-19	81 (39.5%)	9 (4.4%)		
Energy adequacy	Adequate	53 (25.9%)	1(0.5)	11.015	*0.001
	Inadequate	119 (58%)	32 (15.6%)		
Protein adequacy	Adequate	110 (53.7%)	10 (4.9%)	4.025	*0.04
	Inadequate	62 (30.2%)	23 (11.2%)		
Fat adequacy	Adequate	51(24.9%)	3 (1.5%)	6.032	*0.014
	Inadequate	121 (59%)	30 (14.6%)		

In the present study, adolescents aged 10-14 years were more likely to be stunted (11.7%) compared to those aged 15-19 years (4.4%). This may be attributed to the increased nutritional requirements during early adolescence, a critical period of rapid growth, when insufficient nutrient intake can have a greater impact on linear growth. Similar findings was reported in study conducted in Bangladesh (Adams *et al.*, 2021), where early adolescents were more vulnerable to stunting due to higher physiological demands and inadequate dietary intake.

Energy intakes and protein intakes were both significantly associated with stunting in this study. Inadequate intake nutrients increase the risk of poor growth, while adequate intake supports normal development. Similar findings were reported in Indonesia, where adolescents' nutritional status was strongly linked to energy and protein intake. Since protein requirements rise alongside rapid growth, weight and height gain during adolescence, meeting recommended intake levels is essential for achieving and maintaining good nutritional status (Veronica *et al.*, 2021).

In addition, fat adequacy showed a significant association (p=0.0014). Adolescents with inadequate fat intake were more likely to be stunted. overall, these findings underscore that dietary adequacy especially of energy, protein, and fat plays a pivotal role in adolescent growth and prevention of stunting. The results suggest the need for targeted nutrition education and school-based meal programs focusing on balanced diets to meet adolescents' energy and nutrient needs, particularly during early adolescence.

5.17 Factors associated with overweight/obesity and thinness

Table 4.17 shows the factors associated with overweight/obesity and thinness. The factors like age group (p=0.019), religion (p=0.003), energy (p=0.000), protein (p=0.000) and fat (p=0.000) were found to be associated with thinness and obesity analyzed at statistical significance of p<0.05.

Table 5.17 Factors associated with thinness and obesity (n=205)

Factors		**Normal**	**Thinness**	**Obesity**	**χ2 - value**	**p-value (<0.05)**
Age group	10-14	100 (48.8%)	13(6.3%)	2 (1.0%)	0.213	*0.021 f
	15-19	66 (32.2%)	16 (7.8%)	8 (3.9%)		
Religion	Hindu	137 (66.8%)	25 (12.2%)	4 (2%)	11.675	*0.008 f
	others	29 (14.1%)	4 (2%)	6 (2.9%)		
Dietary preference	veg	25 (12.2%)	9 (4.4%)	0 (0%)	6.644	*0.042 f
	Non-veg	141 (68.8%)	20 (9.8%)	10 (4.9%)		
Energy adequacy	Adequate	44 (21.5%)	0 (0%)	10 (4.9%)	38.336	*0.000 f
	Inadequate	122 (59.5%)	29 (14.1%)	0 (0%)		
Fat adequacy	Adequate	41(20%)	3 (1.5%)	10 (4.9%)	32.018	*0.000 f
	Inadequate	125 (61%)	26 (12.7%)	0 (0%)		
Protein	Adequate	101 (49.3%)	8 (4.9%)	9 (4.4%)	15.706	*0.003 f
	Inadequate	65 (31.7%)	21 (9.3%)	1 (0.5%)		

Note: ‘f’ symbol denotes values of Fisher’s exact test or Fisher-Freeman-Halton extension

Age group revealed significant association with BMI-for-age category with obesity being more prevalent among individuals who were in their late adolescence compared to those in early adolescence. A study conducted by Khatri *et al.* (2023) also reported that in relation to the age group, the students of 15–17 years age had a significantly higher prevalence of overweight/obesity than younger age group.

The present study demonstrated a strong association between energy, protein, and fat adequacy with nutritional status among adolescents. Specifically, those with adequate intake of these nutrients were more likely to be categorized as obese, highlighting the potential influence of dietary composition on weight outcomes.

This finding is consistent with previous evidence suggesting that higher protein intake is associated with an increased risk of obesity, with one study reporting a 2.92-fold higher risk among adolescents with excessive protein consumption. Similarly, excessive carbohydrate and fat intake have been shown to elevate the risk of obesity by 2.58 and 6.2 times, respectively (Nur and Simbolon, 2024).

Similarly, energy, protein and fat intakes were also found to be associated with thinness. Supporting this finding, a study conducted among adolescent girls in rural areas of Western Sumatera, Indonesia, reported that low energy and protein intake were significant determinants of undernutrition, with protein intake emerging as the dominant factor contributing to undernutrition (Azrimaidaliza and Masrizal, 2024)

Conclusion and recommendations

This study assessed the dietary diversity, dietary intake and nutritional status of adolescents in Itahari Sub-Metropolitan City. The conclusions that can be drawn from the study are:

a) The prevalence of stunting, thinness and overweight/obese were 16.1%, 14.1%, and 2.8% respectively in adolescents of Itahari Sub-Metropolitan City.

b) Low dietary diversity was observed in adolescents, only accounting for adequate ditetary diversity and for inadequate diversity. Similarly, frequent meal skipping, and high consumption of processed food were common.

c) The nutritional knowledge was found to be good in adolescents, 62.9% accounting for adequate nutritional knowledge while only 37.1% had inadequate nutritional knowledge.

d) Factors such as age group, intake of energy, fat, and protein were associated with overweight/obesity, thinness as well as with stunting. Whereas religion was found to be associated with overweight/obesity.

e) Inadequate dietary diversity was significantly associated with thinness and overweight/obesity.

Recommendations

Based on the study's findings, the following recommendations are proposed to improve the nutritional status and nutrient intake of adolescents:

a) School based nutritional programs can be conducted where adolescents should be encouraged not to skip meals and to increase meal frequency, encouraged to consume a variety of foods, including fruits, green leafy vegetables, pulses, legumes, and nutrient rich foods such as meat, fish, poultry, and dairy products.

b) Cross-sectional surveys should be conducted periodically with special emphasis on the nutritional status of adolescents and other unexplained factors that were not included in the present study.

c) To address teenage nutritional issues and encourage healthy lifestyles, the municipality should create and carry out comprehensive programs in collaboration with families, schools, and other organizations.

Summary

Adolescence is a critical phase in the life course, characterized by remarkable physical growth, physiological, and cognitive development, and biological maturation. Adolescents set the foundation for adulthood and undergo biological and physical changes that require optimal nutrition. These changes are not limited to metabolism, skeletal growth, sexual maturation, menarche, lean and fat body mass, but are underpinned by adequate intake of macro-and micronutrients. Adolescents who eat healthily are less likely to suffer from obesity, osteoporosis, and chronic conditions like diabetes and cardiovascular disease. Conversely, adolescents who eat poorly may develop long-term health problems like delayed sexual maturation and shorter adult stature.

A cross-sectional survey was conducted to assess the dietary diversity and its association with nutritional status of adolescents in Itahari Sub-Metropolitan city, Sunsari district. From randomly selected three school, 205 adolescents were chosen by random selection. A well designed pretested questionnaire was used to collect information on socio-economic conditions, dietary practices, intake and dietary diversity, hygiene and sanitation. Weight and height were measured using a digital weighing balance and a stadiometer. Dietary intake was assess using 24-hour dietary recall and dietary diversity score was evaluate with 10 food groups described by Food and Agricultural Organization. Data were analyzed using WHO Anthro plus version 1.0.4, SPSS version 20 and Microsoft Excel 2019, with Chi-square test and Fishers exact used to assess factors associated with nutritional status.

Among 205 adolescents surveyed, females and males. The prevalence of stunting, thinness, and overweight/obesity was respectively. Furthermore, the prevalence of inadequate nutrient consumption was also alarming, for fat, for protein, and for energy. Statistical analysis revealed significant association with low dietary diversity with thinness and adequate diversity with overweight/obesity (0.029). Thinness and obesity were also found to be associated with age group (0.019), religion (0.003), energy (<0.001), protein (<0.001) and fat intake (0.000) and dietary preference (0.036). Whereas stunting was associated with age group (0.036), energy (0.001), fat (0.014), and protein intake (0.04).

The results show how urgently intervention programs are needed to enhance the eating patterns, nutrient consumption, and nutritional status of adolescents in Itahari Sub-Metropolitan City. Improving adolescent health outcomes requires addressing these problems.

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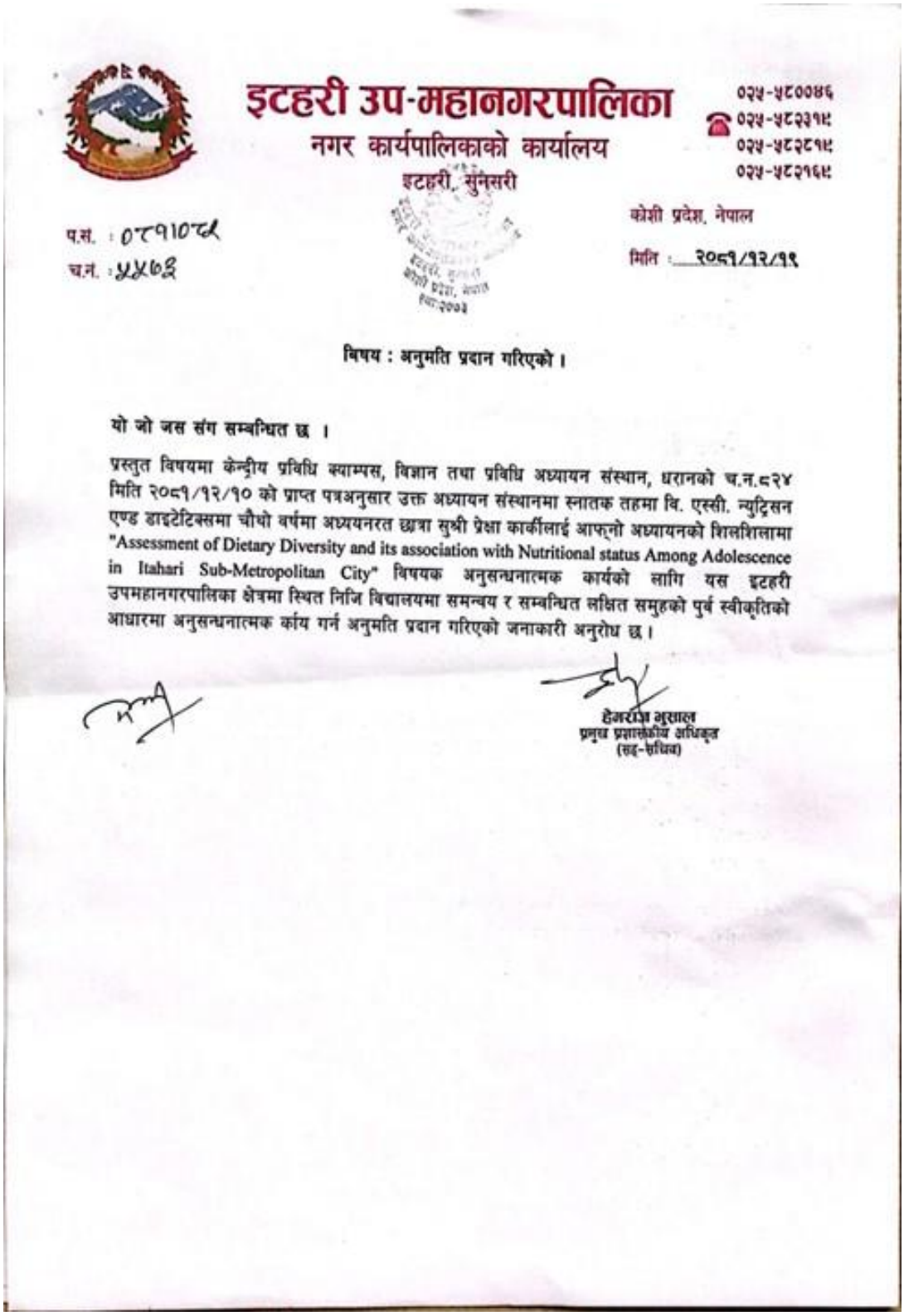
Appendices

7.1 Appendices A Approval letter



इटहरी उप-महानगरपालिका
नगर कार्यपालिकाको कार्यालय
इटहरी, सुनसरी

०२५-५८००४६
०२५-५८२३१५
०२५-५८२८१५
०२५-५८२१६५

कोशी प्रदेश, नेपाल

प.सं. : ०८१।०८२
च.नं. : ५५७९

मिति : २०८१/१२/१९

विषय : अनुमति प्रदान गरिएको ।

यो जो जस संग सम्बन्धित छ ।

प्रस्तुत विषयमा केन्द्रीय प्रविधि क्याम्पस, विज्ञान तथा प्रविधि अध्ययन संस्थान, धरानको च.न.८२४ मिति २०८१/१२/१० को प्राप्त पत्रअनुसार उक्त अध्ययन संस्थानमा स्नातक तहमा वि. एस्सी. न्युट्रिसन एण्ड डाइटेटिक्समा चौथो वर्षमा अध्ययनरत छात्रा सुश्री प्रेक्षा कार्कीलाई आफ्नो अध्ययनको शिलशिलामा "Assessment of Dietary Diversity and its association with Nutritional status Among Adolescence in Itahari Sub-Metropolitan City" विषयक अनुसन्धनात्मक कार्यको लागि यस इटहरी उपमहानगरपालिका क्षेत्रमा स्थित निजि विद्यालयमा समन्वय र सम्बन्धित लक्षित समुहको पुर्व स्वीकृतिको आधारमा अनुसन्धनात्मक कार्य गर्न अनुमति प्रदान गरिएको जनाकारी अनुरोध छ ।

हेमराज भुसाल
प्रमुख प्रशासकीय अधिकृत
(सह-सचिव)

7.2 Appendix B consent form

किशोरकिशोरीहरूको स्वीकृति फारम

अनुसन्धानको शीर्षक: इटहरी उपमहानगरपालिकाका किशोर–किशोरीहरूमा आहार विविधता र पोषण स्थितिबीचको सम्बन्धको मूल्यांकन

मेरो नाम प्रेक्षा कार्की हो, म केन्द्रीय प्रविधि क्याम्पस धरानमा पोषण तथा आहार विज्ञान (बी.एस.सी.) चौथो वर्षकी विद्यार्थी हुँ। यो अनुसन्धान मेरो शैक्षिक कार्यको एक हिस्सा हो।यो अध्ययनले इटहरी उपमहानगरपालिकाका किशोर-किशोरीहरूको आहार विविधता र पोषण स्थितिबीचको सम्बन्ध मूल्याङ्कन गर्ने उद्देश्य राख्दछ। तपाईं किशोर-किशोरी उमेर समूहमा पर्नुहुन्छ र अध्ययनको समावेशी मापदण्डमा पर्नुहुन्छ, त्यसैले तपाईंलाई सहभागी हुन अनुरोध गरिएको हो।

हामी जान्न चाहन्छौं कि किशोरकिशोरीहरूले कुन-कुन प्रकारका खाना खान्छन् र त्यसले स्वास्थ्यमा कस्तो असर पार्दछ। जानकारी सङ्कलनका लागि पूर्वनिर्धारित प्रश्नावली प्रयोग गरी अन्तर्वार्ता लिइनेछ जुन तपाईंले हिजो खाएको खानामा आधारित हुनेछ। तपाईंको उचाइ र तौल पनि मापन गरिनेछ।

- अन्तर्वार्ता गर्न २० देखि ३० मिनेट लाग्नेछ र यो एकपटक मात्र हुनेछ।
- यस अनुसन्धानबाट तपाईंलाई प्रत्यक्ष फाइदा नहुन सक्छ, तर यसले तपाईंको विद्यालय र समुदायलाई किशोरकिशोरीहरूको पोषण बारे बुझ्न मद्दत गर्नेछ।
- प्रश्नहरूको उत्तर दिँदा कुनै जोखिम हुँदैन। उचाइ र तौल मापन गर्दा सामान्य असहजता हुन सक्छ तर तपाईंलाई हानि हुँदैन।
- तपाईंलाई कुनै भुक्तानी दिइने छैन, तर अनुसन्धानमा सहभागी हुन तपाईंलाई कुनै खर्च लाग्दैन।

यदि तपाईं सहभागी हुन चाहनुहुन्न भने यो अनुसन्धानमा सहभागी हुनु आवश्यक छैन। अहिले “हुन्छ” भने पनि पछि “हुन्न” भन्न सक्नुहुन्छ र कुनै पनि बेला रोक्न सक्नुहुन्छ।

अनुसन्धान टोली र सम्पर्क विवरण

यदि तपाईंलाई कुनै जिज्ञासा छ भने तल उल्लेखित व्यक्तिहरूसँग कुरा गर्न सक्नुहुन्छ:

अनुसन्धानकर्ता: प्रेक्षा कार्की फोन: ९८०८८७३४६०

सुपरभाइजर: सुमन पोखरेल फोन: ९८४२११०६०२

तपाईंले दिएका उत्तरहरू गोप्य राखिनेछ र अनुसन्धानका लागि मात्र प्रयोग गरिनेछ। तपाईंको नाम कसैसँग पनि बाँडफाँड गरिने छैन।

स्वीकृति वाक्यांश

मैले यो अनुसन्धान के हो भनेर पढें वा कसैले मलाई पढेर सुनायो। म बुझ्छु र सहभागी हुन चाहन्छु। पछि मेरो विचार फेरिएमा म सहभागी हुन छोड्न सक्छु।

हस्ताक्षर खण्ड

(किशोर/किशोरीको नाम): __ (अनुसन्धानकर्ताको नाम):

(मिति): _____ (हस्ताक्षर): _____

(स्थान): _____

अभिभावकको नाम: _____

हस्ताक्षर

सहमति फारम

अनुसन्धानको शीर्षक: इटहरी उपमहानगरपालिकाका किशोर–किशोरीहरूमा आहार विविधता र पोषण स्थितिबीचको सम्बन्धको मूल्यांकन

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हामी जान्न चाहन्छौं कि किशोरकिशोरीहरूले कुन-कुन प्रकारका खाना खान्छन् र त्यसले स्वास्थ्यमा कस्तो असर पार्दछ। जानकारी सङ्कलनका लागि पूर्वनिर्धारित प्रश्नावली प्रयोग गरी अन्तर्वार्ता लिइनेछ जुन तपाईंले हिजो खाएको खानामा आधारित हुनेछ। तपाईंको उचाइ र तौल पनि मापन गरिनेछ।

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अनुसन्धान टोली र सम्पर्क विवरण

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अनुसन्धानकर्ता: प्रेक्षा कार्की फोन: ९८०८८७३४६०

सुपरभाइजर: सुमन पोखरेल फोन: ९८४२११०६०२

तपाईंले दिएका उत्तरहरू गोप्य राखिनेछ र अनुसन्धानका लागि मात्र प्रयोग गरिनेछ। तपाईंको नाम कसैसँग पनि बाँडफाँड गरिने छैन।

सङ्कलन गरिएको सम्पूर्ण जानकारी अनुसन्धान प्रयोजनका लागि मात्र प्रयोग गरिनेछ। तपाईंको पहिचान गोप्य राखिनेछ। अनुसन्धानको नतिजा वैज्ञानिक पत्रिकाहरूमा प्रकाशित हुन सक्छ तर तपाईंको नाम कतै पनि प्रयोग गरिने छैन।

मैले यो जानकारी पढेको छु वा मलाई पढेर सुनाइएको छ। म अनुसन्धानको उद्देश्य र प्रक्रियालाई बुझ्दछु। म स्वेच्छिक रूपमा मेरो बचालाई यस अनुसन्धानमा सहभागी गराउन तयार छु र आवश्यकता परे जुनसुकै बेला सहभागी हुन छोड्न सक्दछु।

हस्ताक्षर खण्ड

सहभागीको नाम: _____ अनुसन्धानकर्ताको नाम:

हस्ताक्षर: _____ (हस्ताक्षर): _____

मिति: _____

Assent Form for Adolescents

Research title: Assessment of Dietary Diversity and its Association with Nutritional Status among adolescent in Itahari Sub-Metropolitan city.

My name is Prechhya Karki, a B.Sc. Nutritiona and Dietetics fourth year student at Central Campus of Technology, Dharan. I am conducting this research as part of my undergraduate thesis.

This study aims to assess dietary diversity and its association with the nutritional status of adolescent in Itahari Sub-Metropolitan city. You are being requested to participate because you fall within the adolescent age group and meet the inclusion criteria for this study. you will be interviewed individually. Questions will relate to your diet and food consumption in the past 24 hours. Your height and weight will also be measured.

- The interview will take around 20 to 30 minutes and will be done only once.
- This study might not help you directly, but it can help your school and community learn more about adolescent nutrition.
- There is no risk in answering the questions. Measuring your height and weight may cause slight discomfort but will not hurt you.
- You will not be given any payment, but being part of the research will not cost you anything.

Your participation is completely voluntary and you may skip any question or withdraw at any time without penalty or loss of benefits.

Study team contact details:

Researcher: Prechhya Karki contact no: 9808873460/

e-mail:Karkiprechhya@gmail.com

Supervisor: Suman Pokhrel contact no: 9842110602

The answer you give will be kept secret and used only for research. Your name will not be shared with anyone.

Assent statement:

I have read or someone has read to me what this research is about. I understand it and I want to take part. I know I can change my mind later if I want.

Signature section:

Participant name:…….. Researcher name:……..

Signature:……. Signature:……

Date:……

Parent name:……..

Signature:…….

Consent form:

Research title: Assessment of Dietary Diversity and its Association with Nutritional Status among adolescent in Itahari Sub-Metropolitan city.

My name is Prechhya Karki, a B.Sc. Nutritiona and Dietetics fourth year student at Central Campus of Technology, Dharan. I am conducting this research as paet of my undergraduate thesis.

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The answer you give will be kept secret and used only for research. Your name will not be shared with anyone.

Consent statement:

I have read or someone has read to me what this research is about. I understand it and I willingly want to allow my child take part. I know I can change my mind later if I want.

Signature section:

Participant name:…….. Researcher name:……..

Signature:……. Signature:……

Date:……

Parent name:……..

Signature:…….

7.3 Appendix C survey questionnaire

Department of Nutrition and Dietetics

Dharan, Hattisar

SURVEY QUESTIONNAIRES FOR ADOLESCENTS

A. **General information**: Date of interview (B.S.):

DD	MM	YYYY

School's code:	Students code no:
Name:	Class: Age:
Adress: Letang municipality Ward no.:	Date of birth:

1. Gender

a) Male b) Female

2. Caste/Ethnicity:

a) Brahmin b) Chhetri c) Rai d) Limbu

e) Tharu f) Others: ……

3. Religion:

a) Hindu b) Muslim c) Christian

d) Buddhist e) Others: **……**

B. Anthropometric information:

Measurement	Reading 1	Reading 2	Reading 3	Mean reading
Height (cm)				
Weight (kg				

C. Family information

4. Type of family: a) Nuclear b) Extended

5. Number of family member: ……. 6. Number of male members: …….

7. Number of female members: …….. 8. Number of children (0-10 years) ……..

9. Number of adolescents (10-19 years) …….

10. How many siblings do you have (siblings from same parents)?

Total: ……. Brothers: …… Sisters: ……..

11. Your sequence among siblings (from the eldest): ……..

12. Occupation (of father):

a) Agriculture b) Service c) Labor

d) Business e) Foreign employment f) Others: _____

13. Occupation (of mother):

a) Housewife b) Agriculture c) Service

d) Labor e) Foreign employment f) Business

g) Others: _____

14. Family income:

a) Less than Rs. 30000 monthly b) Equal to or more than Rs. 30000 monthly

15. Father's Education level:

a) Higher secondary or above b) Secondary c) Primary Level

d) Informal e) Illiterate

16. Mother's education level:

a) Higher Secondary or above b) Secondary c) Primary level

d) Informal e) Illiterate

17. Which is your main source of drinking water in your family?

a) Pipelines/Tap water b) Well c) River d) Others: ……

18. Is the water purified?

a) Yes b) No

19. Do you have toilet facility in your house?

a) Yes b) No

20. When do you wash your hand? (multiple response)

a) Before having meal b) After having meal
c) After defecation d) Others _____

D. Physical activities

21. On an average, how many hours do you sleep in a day?

a) 5 or less hours b) 6 hours c) 7 hours d) 8 or more hours

22. Which form of transport do you normally use when travel to and from school and apart from your journey to and from school?

a) Private vehicle b) Cycle

c) Public/school transport d) Walk

23. How many hours per day do you spend on doing your homework?

a) None b) Less than an hour a day

c) 1 to 2 hours a day d) More than 2 hours a day 10

24. Do you spend more than 2 hours per day watching television or playing computer games or using mobile phones?

a) Yes b) No

If yes, how many hours per day? _____

25. Does the family watch television/browse phone during meals?

a) Yes b) No

26. What do usually do at school breaks?

a) Sitting down (talking, reading or eating) b) Standing or walking around

c) Running or playing games

27. Do you normally play games or perform physical activities outside school? a) Yes b) No

If yes, what type?

a) Play games b) Aerobics/Dance c) Swimming

d) Gym e) Running/jogging f) Walking

g) Yoga

In a day, how much time do you do such activities? ..... Hours/Minutes

How frequently in a week? _____

28. Do you help your parents in doing domestic activities?

a) Yes b) No

If yes, how much time in a day do you involve in domestic activities? _____ Hours

E. Dietary intake and food habits

29. What are you?

a) Vegetarian b) Non vegetarian

30. Do you skip any meal?

a) Yes b) No

If yes, which meal does you skips?

a) Breakfast b) Lunch c) Dinner d) Snacks

31. What is the main reason for skipping meal?

a) For weight loss b) Poor appetite c) Health conscious

d) No time to have meal e) Due to food deficient f) Other _____

32. How many glasses (250 ml) of water do you drink/day?

a) One b) Two to four

c) Five to seven c) Eight or more

33. Do you have daily pocket money?

a) Yes b) No c) Sometimes (_____times a week)

34. Do you buy food from school canteen/ shops /vendor?

a) Yes b) No

If yes, what do you usually buy? _____

35. Where do you take your tiffin from in a day?)

a) From school canteen b) Take from home c) Other (Specify)_____

36. Do you smoke?

a) Yes b) No

37. Do you drink alcoholic beverages?

a) Yes b) No

38 When did you take drugs for intestinal worms?

a) Within a month b) Within 6 months c) Don't know

39. Are you taking iron/ folic acid? (For menstruating females)

a) Yes b) No

If yes, where did you get that iron/folic acid?

a) Pharmacy b) Health post c) Others (specify _____

F. Nutrition Knowledge

40. Do you know about **nutrition**? a) Yes b) No

41. Do you know about **malnutrition**?

a) Yes b) No

If yes, what is the cause of malnutrition?

a) Inadequate food b) Superstition

c) Unhygienic food practices d. Other _____

42. In your opinion, why should we eat nutritious food?

a) For adequate physical growth b) For adequate mental growth

c) For immunity power development d) Don't know e) Others (specify) _____

43. Do you know about **vitamin A**?

a) Yes b) No

44. Do you know what causes night blindness?

a) Deficiency in vitamin A b) Deficiency in iron c) Deficiency in minerals

d) Deficiency in iodine e) Deficiency in others vitamin f) Don't know

45. Do you know about Iron?

a) Yes b. No

46. Do you Know about anaemia?

a) Yes b. No

47. What causes anemia?

a) Deficiency in vitamin A b) Deficiency in iron c) Deficiency in minerals

d) Don't know

48. In your opinion, why should we use Iodized salt?

a) To help children grow b) To prevent goiter c) To improve school performance

d) Don't know

G Dietary Diversity Score

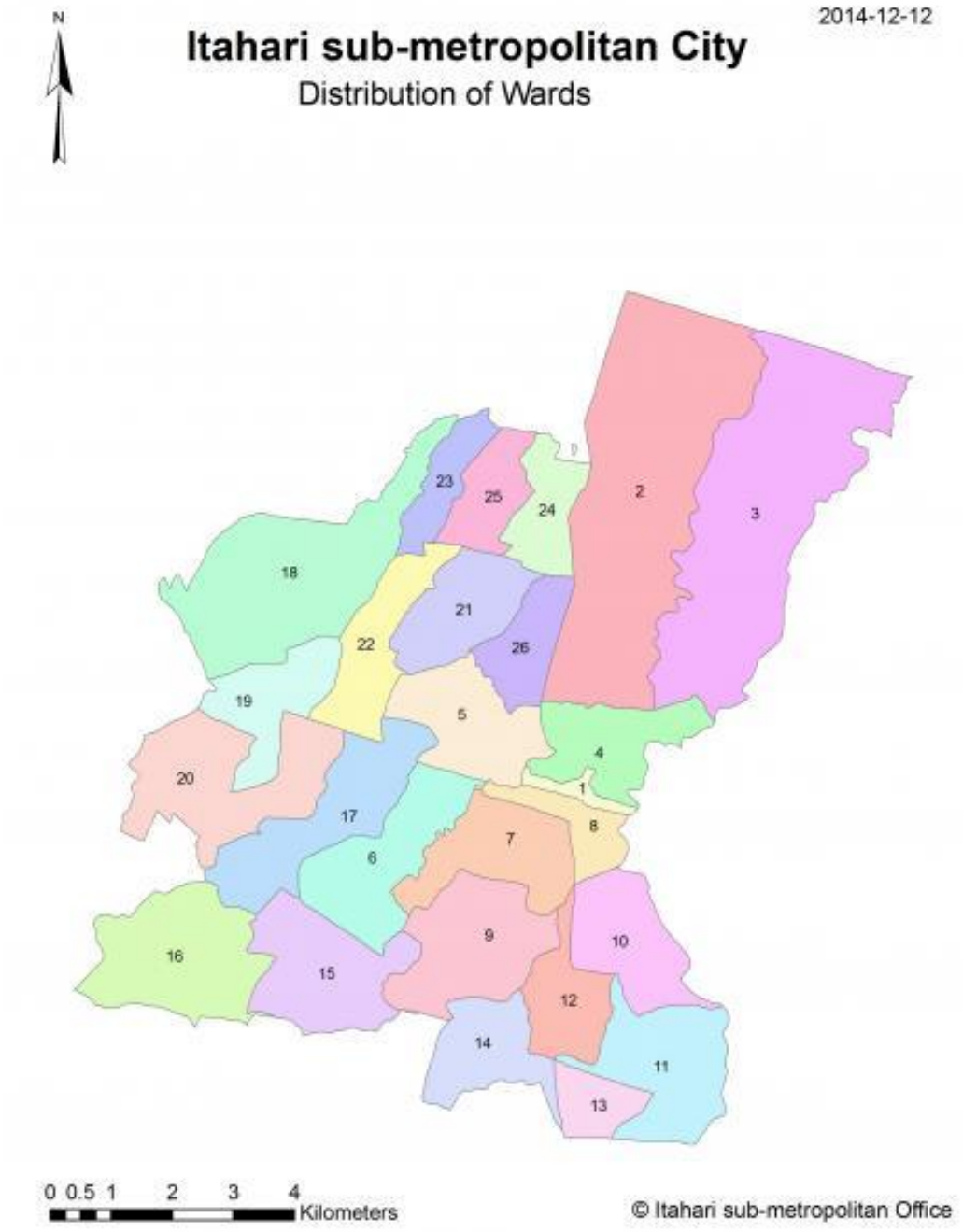
Question number	Food groups	Yes/no
1.	Grains, white roots and tubers	
2.	Legumes and pulses	
3.	Milk and milk products	
4.	Meat, fish, poultry and organ meat	
5.	Eggs	
6.	Green leafy vegetables	
7.	Other vitamin A rich fruits and vegetables	
8.	Other fruits	
9.	Other vegetable	
10.	Nuts and seeds	

H. 24- hour diet recall

Time	**Description of food**	**Portion**	**Amount**	**Remarks**
Breakfast (6-8 am)				
Lunch (9-11am)				
Mid-day Snacks (12-3pm)				

Evening snacks (4-6 pm)				
Dinner (7-10pm)				

7.4 Appendix D Survey site



7.5 Appendix E photo gallery

a. Assessment of height of adolescent

c. Interview of adolescent

b. Standardized utensil used for 24 hour diet recall

7.6 Appendix F Association of malnutrition with study variables

Factors	Normal	Stunted	Chi-square	p-value	Normal	Thinness	Obesity	Chi-square	p-value
Gender			0.523	0.469				0.213	0.922 f
Male	90	15			84	16	5		
Female	82	18			82	13	5		
Age group			4.416	0.036				7.944	0.021 f *
10-14	91	24			100	13	2		
15-19	81	9			66	16	8		
Religion									
Hindu	141	25	0.695	0.404	137	25	4	11.675	0.008 f *
Others	31	8			29	4	6		
Ethnicity									
Brahmin and Chhetri	100	14	3.358	0.187	92	19	3	11.912	0.049 f *
Janajati and Dalit	47	14			51	8	2		
Madhesi	25	5			23	2	5		

Factors	Normal	Stunted	Chi-square	p-value	Normal	Thinness	Obesity	Chi-square	p-value
Family Type			0.016	0.900				5.496	0.061 f
Nuclear	75	14			77	11	1		
Extended	97	19			89	18	9		
Family member			0.134	0.715				1.730	0.421
Below average	77	12			71	8	10		
Above average	94	17			80	12	19		
Family Income			0.008	1.000 f				0.334	0.920 f
>30,000	25	5			24	5	1		
<30,000	147	28			142	24	9		
Siblings in family			0.988	0.610				3.146	0.534
No siblings	33	4			28	8	1		
One	88	19			90	12	5		
Above one	51	10			48	9	4		
No of adolescent			0.007	0.932				1.499	0.473
one	82	16			76	16	6		
more than one	90	17			90	13	4		
Fathers' education			0.005	1.000 f					
Literate	161	31			154	28	10	1.306	0.521

Illiterate	11	2		12	1	0		

Factors	**Normal**	**Stunted**	**Chi-square**	**p-value**	**Normal**	**Thinness**	**Obesity**	**Chi-square**	**p-value**
Mothers' education									
Literate	165	32	0.080	1.000 f	159	28	10	0.466	1.000 f
Illiterate	7	1			7	1	0		
Fathers' occupation									
Agriculture and labor	33	5	0.360	0.835	29	8	1	4.038	0.446 f
Service and business	91	19			87	16	7		
Foreign employment	48	9			50	5	2		
Mothers' occupation			1.923	0.166				5.708	0.057 f
Housewife	134	22			121	25	10		
Working mother	38	11			45	4	0		
Is Water Purified?			0.009	0.927				3.519	0.164 f
Yes	129	25			123	21	10		
No	43	8			43	8	0		
Factors	**Normal**	**Stunted**	**Chi-square**	**p-value**	**Normal**	**Thinness**	**Obesity**	**Chi-square**	**p-value**
Dietary preference									
Veg	30	4	0.567	0.452	25	9	0	6.644	

									0.042 f *
Non-Veg	142	29			141	20	10		
Meal Skipping			1.663	0.197				4.601	0.101 f
Yes	114	18			110	14	8		
No	58	15			56	15	2		
Form of transport									
Vehicle	39	3	2.321	0.128	30	3	9	2.311	0.315
Walk	132	26			121	17	20		
Sleep hours									
8 or more hours	72	18	3.999	0.043*	72	10	8	4.194	0.123
7 or less hours	99	11			79	10	21		
Pocket Money									
Yes	114	15	5.147	0.023	99	20	10	7.114	0.021 f
No	58	18			67	9	0		
Tiffin Sources			2.196	0.138				6.299	0.43 f
School canteen	112	17			98	22	9		
Home	60	16			68	7	1		
Energy intake			11.015	0.001*				38.336	0.000 f *

Inadequate	119	32			122	29	0		
Adequate	53	1			44	0	10		
Protein intake			12.917	0.000*				15.706	0.003 f *
inadequate	62	23			65	21	1		
adequate	110	10			101	8	9		
Fat intake			6.032	0.014*				32.018	0.000 f *
Adequate	51	3			41	3	10		
Inadequate	121	30			125	26	0		
Nutritional knowledge			2.196	0.138				5.645	0.066 f
Adequate	112	17			108	113	8		
inadequate	60	16			58	16	2		
DDS			0.000	0.995				7.097	0.016 f *
Inadequate	125	24			115	27	7		
Adequate	47	9			51	2	3		

Note: ‘f’ symbol denotes values of Fisher’s exact test or Fisher-Freeman-Halton extension