Determinants of Linear Growth among Children Aged under Five Years in Nepal

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Thesis Title Determinants of Linear Growth among Children Aged under Five Years in Nepal

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ชื่อวิทยานิพนธ์	ปัจจัยที่มีผลต่อการเจริญเติบโตเชิงเส้นของเด็กอายุต่ำกว่าห้าขวบประเทศเนปาล
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บทคัดย่อ

การเจริญเติบโตเชิงเส้นที่ไม่เป็นไปตามเกณฑ์ (linear growth faltering) เป็นปัญหาที่เกิดจากการขาดภาวะโภชนาการที่ดี ถึงแม้ว่าปัญหานี้จะได้มีการแก้ไขในประเทศเอเซียใต้ แต่ประเทศเนปาลยังคงมีปัญหานี้อยู่ในเด็กอายุต่ำกว่าห้าขวบร้อยละ 41 ดังนั้นการศึกษานี้มีวัตถุประสงค์เพื่อหาปัจจัยทางด้านประชากร และเศรษฐกิจสังคมที่มีผลต่อการเจริญเติบโตของเด็กอายุต่ำกว่าห้าขวบในประเทศเนปาล โดยใช้ข้อมูลการสำรวจสภาวะสุขภาพประชาชนประเทศเนปาล (Nepal Demographic Health Survey: NDHS) พ.ศ. 2554 การศึกษานี้มีหน่วยตัวอย่างทั้งหมดจำนวน 2,330 คน ตัวแปรตามคือส่วนสูงเทียบกับส่วนสูงมาตรฐานในเด็กอายุเท่ากัน เพศเดียวกัน (Height for Age Z score) เปรียบเทียบค่าเฉลี่ยของตัวแปรตามจำแนกตามปัจจัยต่าง ๆ โดยใช้ การทดสอบ t-test และการวิเคราะห์ความแปรปรวน (ANOVA) และใช้การวิเคราะห์การถดถอยเชิงเส้นแบบพหุ (Multiple linear regression) เพื่อหาความสัมพันธ์ระหว่างปัจจัยต่าง ๆ กับการเจริญเติบโต ผลการศึกษาพบว่าการเจริญเติบโตของเด็กที่มีอายุต่ำกว่าห้าขวบประเทศเนปาล มีค่าเฉลี่ยเท่ากับ -1.73 และค่าส่วนเบี่ยงเบนมาตรฐานเท่ากับ 1.48 และตัวแปรที่มีความสัมพันธ์กับการเจริญเติบโตได้แก่ สถานะภาพทางสังคม การศึกษาของมารดา ส่วนสูงของมารดา สภาพทางภูมิศาสตร์ และที่อยู่อาศัย โดยตัวแปรที่มีความสัมพันธ์เชิงลบกับการเจริญเติบโตคือ ครัวเรือนที่ยากจน กลุ่มเด็กที่มีอายุมากกว่า มารดาที่ไม่มีการศึกษา และอาศัยอยู่ในพื้นที่ชนบท

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ABSTRACT

Linear growth faltering is one chronic form of malnutrition which is more serious in children due to its irreversible nature. Linear growth faltering among under five years children in Nepal, despite of rapid improvement of the status in South Asia, is still 41%. The aim of this study is to investigate socioeconomic and demographic determinants of linear growth among children aged under five years in Nepal. Data were obtained from the Nepal Demographic Health Survey (NDHS), which was conducted in 2011. The linear growth (Height for Age Z score) of 2,330 children was examined. T- test and Analysis of variance (ANOVA) were used to compare the mean of the outcome. Multiple linear regression was used to determine associated factors of linear growth. The mean and standard deviation of linear growth of Nepalese children under 5 year was found to be -1.73 ± 1.48. Results indicated that the children's linear growth was affected negatively due to various contextual factors including varied socioeconomic status, mother’s educational attainment and height, geographical region and place of residence. The poorest households, older age of children, mother's having no education and living in a rural area were found to be negatively associated with linear growth.

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I am particularly thankful to Thailand's Education Hub for Southern Region of ASIAN Countries (TEC-AC) scholarship for providing the scholarship. I am also grateful to Nepal Demographic Health Survey (NDHS).

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Sumitra Kattel

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List of Acronyms

ANOVA	Analysis of Variance
DHS	Demographic Health Survey
HAZ	Height for Age Z score
MOHP	Ministry of Health and Population
NDHS	Nepal Demographic and Health Survey
PSU	Primary Sampling Units
SD	Standard Deviation
WAZ	Weight for Age Z score
WHO	World Health Organization
WHZ	Weight for Height Z score

Chapter 1

Introduction

1.1 Background and rationale

Growth of children is a principal component of nutritional status which indicates their health and well-being. Growth can be measured impartially by using various anthropometric measurements. Anthropometric measurement is low-cost, reliable and accurate, it reveals both short and long term nutritional status of children (Beker, 2006). There are various measures for calculating anthropometric indices. Among them, height for age Z score (HAZ), weight for height Z score (WHZ) and weight for age Z score (WAZ) provides the comprehensive description of growth. HAZ score shows linear growth, WHZ reflects body proportion, and WAZ represents combination of both linear growth and body proportion (Onis *et al*., 1993; Onis and Blossner, 1997).

Among mentioned anthropometric indices, study focuses only on indices which shows linear growth i.e. HAZ score. Linear growth of children has been considered as the best indicator of good health (Onis *et al*., 2004). Linear growth is the growth of a child in a linear scale and linear growth faltering is the growth deficit in the child. HAZ score below -2 standard deviation (-2SD) indicates linear growth faltering which is called stunting. Linear growth faltering is an indicator of previous growth failure, which is a sign of poor nutritional history (Black *et al*., 2008). It is also found that faltered linear growth is linked with decreased cognitive ability (Sudfeld *et al*., 2015). Linear growth faltering is one of serious indicator of malnutrition (Black *et al*., 2008)

Malnutrition is a major concern which threatens the world's sustainable development goal (SDG's). The sustainable development goal 2 aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture (Osborn *et al*., 2015). Children's nutritional status is one indicator, contributing in achieving the sustainable development goal 2. (International Food policy Research Institute, 2015). Malnutrition can be seen in various types skinny appearance to obesity, nutrition-related non communicable diseases and poor growth among children. Malnutrition affects all countries and one in three people on this earth. Nearly half of all countries face multiple serious burdens of malnutrition such as poor child growth, micronutrient deficiency, and adult overweight (International Food policy Research Institute, 2015; Rice *et al*., 2000).

In most developing countries, malnutrition is regarded as under nutrition (World Food Program, 2005). The cost of under nutrition is high in many developing countries. Linear growth faltering and other conditions related to growth were liable for globally 2.2 million deaths and 21% of disability adjusted life years (DALYs) among under 5 years children (Black *et al*., 2008). Under nutrition in children is one of the leading contributors to morbidity and mortality related to children in the whole world especially in low income and middle income countries (Egata *et al*., 2013).

Childhood linear growth faltering in south central and south eastern Asia posses second very high magnitude. It has greater level of problem which reflects the long term nutritional deficiencies and illness (UNICEF, 2009). Nepal was ranked on the top 10 countries with the highest burden of malnutrition with the highest prevalence of linear growth faltering and grouped among the top 20 countries with the highest burden of linear growth faltering among under 5 years children worldwide (UNICEF, 2009). Recent Nepal demographics health survey (NDHS) report shows the prevalence of linear faltering is 41 percent among under 5 year children in Nepal which is nearly half among the total children in 2011 (MOHP and New ERA, 2011).

Nepal has one of the highest growth faltered child population in the world. In recent report, the United Nations Children's Fund (UNICEF) showed that Nepal has third highest child linear growth faltering among South Asian countries after India and Afghanistan (UNICEF, 2015). Short or long term nutritional deficiency among children in their growth and development period threaten the proper physical, cognitive, and behavioral skills of children followed to adulthood (Behrman and Rosenzweig, 2004). Hence, linear growth faltering affects individually which ultimately negatively affects the national economy (World Bank, 2008).

Nepal is on the progress to almost achieve the Millennium Development Goal (MDGs) target for child mortality, despite this progress target for infant mortality is still far and is found that malnutrition is one obstacle to accomplish the target (Malla *et al.*, 2011). Linear growth faltering is also one indicator to monitor first goal of MDGs "to halve between 1990 and 2015 the proportion of people who suffer from hunger" (Black *et al*., 2008).

Infections during childhood and improper feeding practices, sociopolitical factor, environmental factor and economic factors are factors affecting the physical and mental growth of the children (Onis *et al*., 2000; Black *et al*., 2008). Various studies revealed that socio demographic factor lifestyle and behavior factors are associated with the prevalence of linear growth faltering in many developing countries (Espo *et* *al*., 2002; Rayhan and Khan, 2006; Tiwari *et al*., 2014). In Nepal social determinants affecting linear growth are important and needs to be assessed. So this study will explore the social determinants associated with linear growth of under five year children in Nepal.

1.2 Objective

To explore the factors associated with linear growth among under five years Nepalese children

1.3 Literature reviews

Most studies found were mainly concerned about linear growth faltering and its associated factors. In this section, literature applicable to this study were reviewed under the subheading, prevalence of linear growth faltering and its severity, factors associated with linear growth faltering and statistical methods used and their findings.

1.3.1 Prevalence of linear growth faltering and its severity

1.3.1.1 Prevalence in the world

Around the world linear growth faltered children are dropping down although 159 million children were affected (UNICEF and WHO, 2015). The prevalence of linear growth faltering in least developed countries (LDCs) is seems to be decreased from 60% in 1990 to 38% in 2011. However increasing number of under-five population in those countries result in the increase in number of linear growth faltered children in LDCs. This rate of decline hinder to achieve the target set in 2010 to have 40% reduction in the global number of children under-five years of age who are linear growth faltered by 2025 (UNICEF and WHO, 2012). Worldwide around 25% of children were facing adverse effect on linear growth (UNICEF, 2015).

1.3.1.2 Prevalence in South Asian and African Countries

A study of Vietnamese children of under 3 years old (Hien and Hoa, 2009) among the 383 children more than one third (36.6%) were had faltered growth. In another study done from the data of Bangladesh demographics Health Survey (BDHS) it is found that almost half of the children (45%) of under 5 year children had faltered linear growth (Rayhan and Khan, 2006). A study done by Egata *et al*. (2013) investigated the seasonal variation in the prevalence of linear growth faltering among children under 5 years of age in east rural Ethiopia and found the prevalence of linear growth faltering to be 7.4% in wet season and 11.2 % in dry season.

Ninety percent of the developing world's growth faltered children can found in the Asia and Africa (UNICEF, 2009). A cross sectional study conducted by Onis *et al*. (2000) showed that linear growth faltering is pervasive in South-central Asia which is on improving trend. The estimated prevalence of linear growth faltering in 2000 was 43.7%, representing a substantial decrease of 0.86 % per year from the prevalence of 60.8% for 1980. It remained 49% in 1990. Ultimately prevalence of linear growth faltering in Asia reached to 28% in 2010, which shows the remarkable declination compared to past (Onis *et al*., 2011). However the prevalence of linear growth faltering among South Asian countries (Afganistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Srilanka) is still 38% in 2015 which is three fold compared to East Asia and Pacific 12% (UNICEF, 2015).

In Nepal, each year 54 under 5 year children die among 1,000. Among those total deaths 45% were associated with under nutrition (Chaparro *et al.*, 2014). Recent National Survey, Nepal Demographics Health survey (NDHS) report shows that prevalence of stunting seems in the decreasing trend, from 50% in 2001 to 41% in 2011, which is not the fast reduction. Severity of linear growth faltering among children in some parts of the country is even higher in comparison with the national average (MOHP and New ERA, 2011). Despite of this little progress in the situation linear growth faltering remains as a major public health problem in Nepal.

1.3.2 Statistical methods used and associated factors with linear growth faltering

A study conducted in Nepal used survey logistic regression model (Tiwari *et al.*, 2011) and found that household wealth index, perceived size of baby at birth, and breastfeeding for more than 12 months were the factors associated with linear growth faltering. It is also seen from the study that increasing age of children is associated with linear growth faltering (Tiwari *et al.*, 2011). The major reasons were improper timing and varieties at the period of weaning (Khanal *et al.*, 2013; Marquis *et al.*,1997). In contrary to this result, study done by Espo *et al.* (2002) revealed that linear growth faltering is persistent throughout the infancy, not only in later age. This conflicting result may be due to the different socioeconomic conditions, geographic variation and breastfeeding practice of mother as well as various differences in feeding and cultural practice. Study conducted in Peru applied multiple linear regression model to find the association between breastfeeding frequency and other descriptive variables with linear growth (Marquis *et al.*, 1997) and found that it is inappropriate to consider the direct association with breastfeeding alone, there might be interaction between the complementary feeding and diarrheal episode with breastfeeding.

Study done by Cesarea *et al*. (2015) in Pakistan used the complex survey logistic regression model there by shows significant association between geographical inequalities in children's nutritional status which is consistent with the report of World food program (Rader *et al*., 2012). Previous studies done in Nepal also shows that children from western mountain region have faltered linear growth with compared to other ecological zone (Tiwari *et al*., 2011). This result has probable association with Hunger Index scores in these areas of Nepal. According to previous study Hunger Index score of Nepal is very high around 21 which indicates the alarming situation of hunger in the country and specially far western and mid western mountain region are close to or above 30, and it is difficult to see any sub region in either the moderate hunger or low hunger categories (Hollema and Bishokarma, 2009).

A study conducted in Nepal suggests that mother education and wealth index are important factor associated with the nutrition of children in Nepal (Crum *et al*., 2012). Study done in Thailand by Mongkolchati *et al*. (2010) has used generalized estimating equation model for factors affecting child linear growth faltering from birth to 2 years which shows mother with primary education, lowest wealth group and small height is significantly associated with linear growth faltering.

Study in Bangladesh by (Rabbi and Karmaker, 2014) used factor analysis to find the factors associated with nutritional status of under 5 year children in Bangladesh using Bangladesh Demographic Health Survey (BDHS) 2011 and found that birth interval, size at birth, mother's body mass index at birth and parent's education were the main factor associated with linear growth of under 5 year children. Children who were considered as small by their mother at birth were negatively associated with linear growth. This was consistent with the findings of other studies done in Bangladesh and Brazil (Rayhan and Khan, 2006; Vitolo *et al*., 2008). They used cox's linear logistic regression model to find the association from their study they also found that children from mothers who could not read were negatively associated with linear growth, and this is supported by a previous study on linear growth faltering (Rayhan and Khan, 2006).

1.4 Scope of the research

The analysis will find out the status of linear growth and social determinants associated with linear growth of under five years children in Nepal using appropriate statistical methods.

1.5 Operational definitions of variables

Some of the terms that are used in this thesis are as follows:

Anthropometric measurement: Measurements of Height, Weight, Arm Circumference and Skinfold thickness of the child in order to find out the nutritional status of the children. There are three indices of anthropometric measurement. In this study HAZ score is used indices of anthropometric measurements.

HAZ Score: Height-for-age Z score is a measure of linear growth.

Linear growth faltering: Children whose height-for-age is more than two standard deviations below the median of the reference population are considered short for their age and are classified as moderately or severely linear growth faltered.

1.6 Conceptual framework of the study

The conceptual framework explains the overall study. This highlights on the issues of the study, consequences and the contextual factors which are directly or indirectly associated with household and individual factors which ultimately cause the issues.

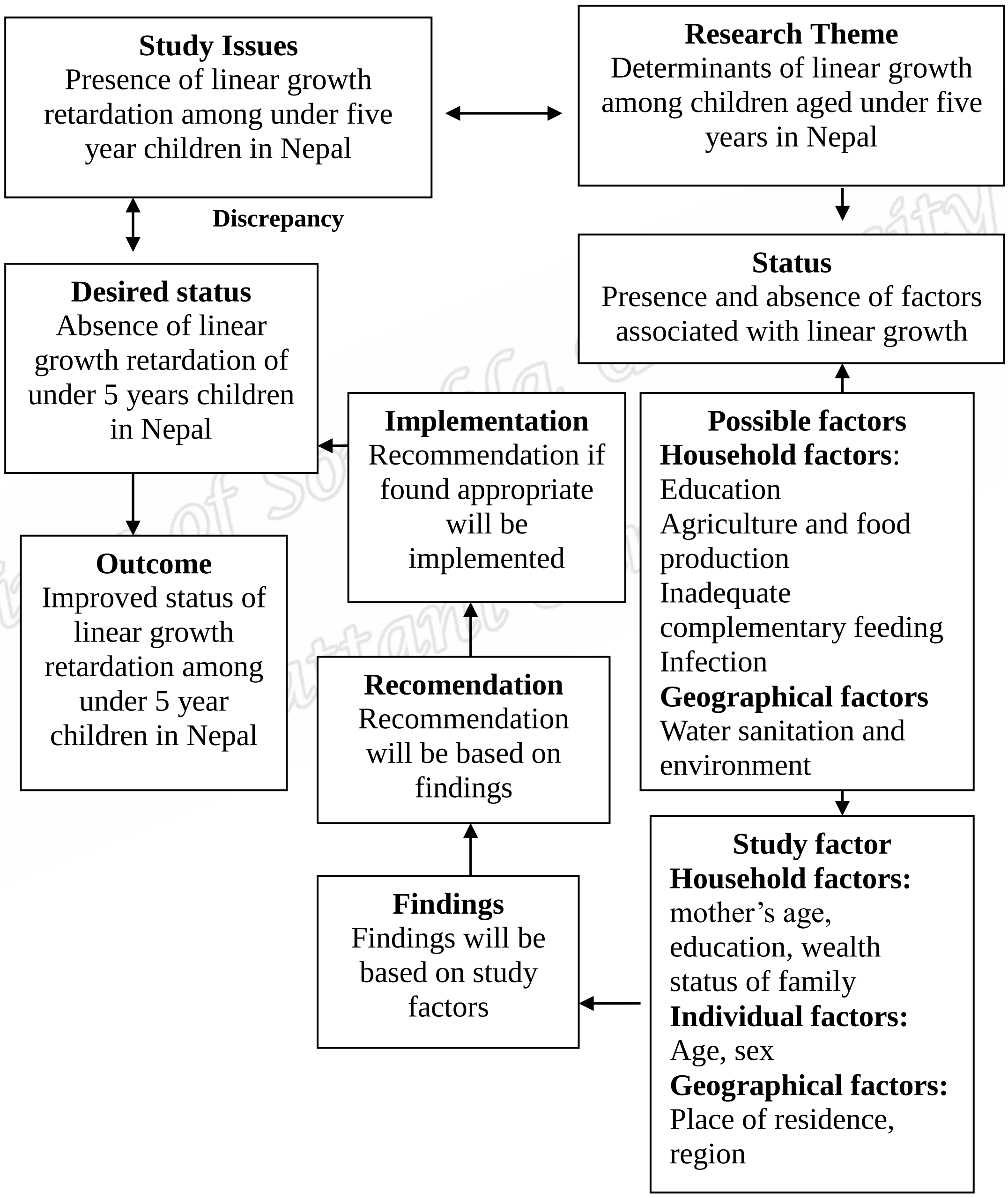

Figure 1.1: Conceptual framework of the study

Figure 1.1 shows the conceptual frame work of the study. The Main issue of the study is presence of linear growth retardation among under five year children in Nepal and the theme is determinants of linear growth among children aged under five years in Nepal. There are many possible determinants for linear growth. However, study factors includes household factors such as mothers age, education and wealth status of family, individual factors, age and sex of the child, and geographical factors place of residence and region in this study. Univariate analysis and statistical modeling will be done further to find the association between study factor and linear growth. Implementation and recommendation will be based on findings. Improved status of linear growth retardation among under 5 year children in Nepal will be the expected outcome of this study.

1.7 Outline of the thesis

This thesis contains four chapters, introduction, methodology, preliminary analysis statistical analysis, conclusion and discussion.

The first chapter introduction provides the introduction of the thesis, objectives of the study, some of the relevant literature reviews regarding the study and some of the operational definition of the terms used in the study.

Second chapter discusses on the methodology used for the collection of the data as well as during the analysis results.

Third chapter presents the graphs and tables of preliminary analysis and the overall statistical analysis.

Fourth chapter summarizes the study by stating the conclusion and recommendation for the study.

Chapter 2

Methodology

This chapter describes the overall methodology used in this thesis. It consists of all aspects of methodology and organizes it in subheading including a discussion of study design, data sources, approach of data collection, study area, data management, study diagrams and overview of the statistical methods for data analysis associated to the statistical models.

2.1 Study design

The descriptive and cross sectional survey was conducted to analyze 2,320 under five years children from Nepal Demographic Health Survey (NDHS, 2011) with the application of linear regression model.

2.2 Data Source and sample

The data for the study were obtained from NDHS 2011. This survey is cross sectional in design. This survey was carried out at every 5 year and is sixth nationally representative comprehensive survey. This survey provides data on anthropometric measurement of children under 5 years age at individual level which helps to analyze factors related with determinants of linear growth among children under 5 years of age.

The federal demographic republic of Nepal is divided into 75 districts and three geographic regions; Mountain, Hill and Terai and five developmental regions; Eastern development region, Central development regions, Western development regions, Mid western development regions, and Far western development regions. In the NDHS survey cross classification of the three ecological zones by the five development regions was done which results 15 eco development regions, which referred to in the NDHS 2011 as subregions or domains. However the western, Mid western and Far western mountain regions were combined to form a single region because of their small population size, resulting in a total of the 13 domain. These domains were further stratified into urban and rural. This results total 25 sampling strata. The majority of population in Nepal resides in the rural areas. In order to provide national urban estimates, urban areas of the country were oversampled. An enumeration area (EAs) is defined as a ward in rural areas and a sub ward in urban areas. Figure 2.1 shows the study areas shown by 289 black dots which denote EAs selected at the first stage of sampling by two stage stratified cluster sampling.

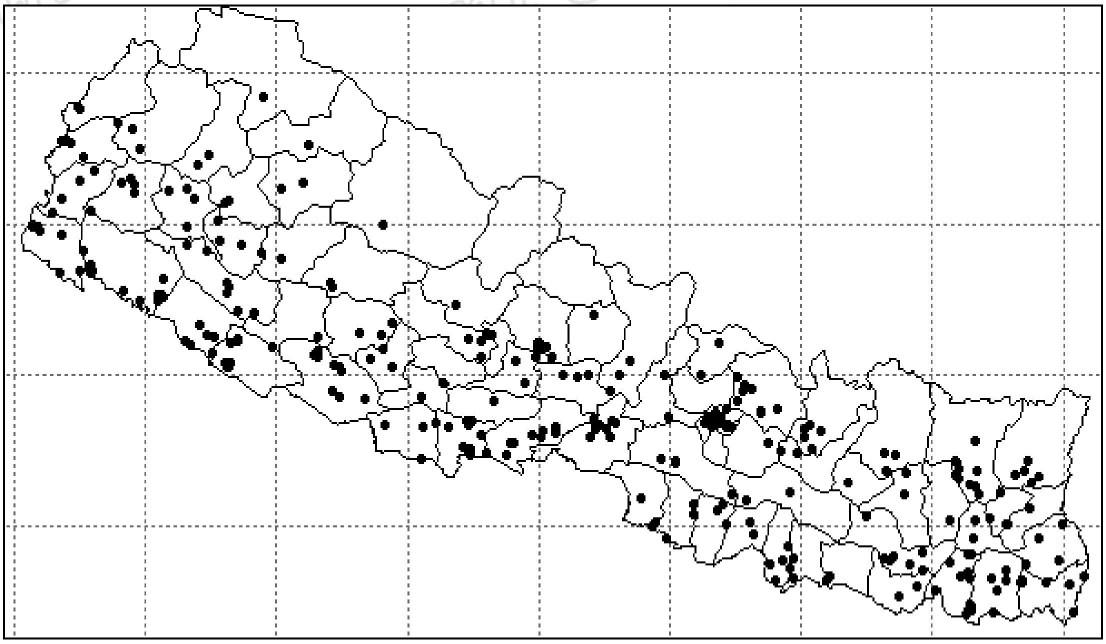

Figure 2.1: Study Areas showing 289 clusters selected at the first stage of sampling

2.3 Sampling design and sample size

Two stage stratified cluster sampling was applied to produce representative sample in this survey. In the first stage enumeration Areas (EAs) were selected using a probability proportionate to size sampling, resulting in 95 urban EAs and 194 rural EAs. A listing of the household and mapping was carried out in all selected EAs. In the second stage 35 households from one urban EA and 40 household from one rural EA selected randomly.

Data collection was carried out in 10,826 out of 11,353 households. In those selected households, 12,918 women were identified as eligible for interview and among them 12,674 were recruited and interviewed. Of the 4,323 eligible man identified in selected subsample of households, 4,121 were interviewed. From these records 7 types of data were generated, these are household recode, household member recode, individual women's recode, male recode, couple's recode, children's recode, birth recode. Among these records this study uses the children's recode.

The sample size included total 2,392 children under 5 years of age from selected subsample of 1,780 household. Among them 59 children were excluded. The reason for exclusion is unavailability at the time of measurement and refusal from their mothers to take measurement for 32 children and remaining 27 were twins or were from the multiple births. Multiple births were excluded from the study on the basis that multiple births affect linear growth faltering (Mbuya *et al.*, 2010). Data from one child is discarded during the calculation of HAZ score from WHO anthro which is flagged as outliers.

The sample size included total 2,332 children under 5 years of age from selected subsample of 1,780 household which were selected for anthropometric measurement of the children.

A Previous study reported the associated factors with linear growth faltering among under five year children using the same dataset. They have examined 2,380 children of under five year using logistic model. In this study outcome variable is measured as a continuous outcome.

2.4 Variables and path diagram of the study

2.4.1 HAZ score

In this study linear growth of the children is the measurement of interest. Linear growth of the children is measured by adjusting the height of the children with age, which is the outcome of this study. HAZ score in this study were calculated by using WHO Anthro software (WHO, 2006). HAZ score is the deviation of the value for individual children from the median value of the reference population of the children, divided by the standard deviation for the reference population. Based on the definition provided by the WHO, HAZ score conveys a child’s height in terms of the number of standard deviations above or below the median height of healthy children from a reference group.

Children whose HAZ score is below two standard deviations of the median of the reference population reflected as short for their age and are classified as moderately or severely linear growth faltered. Linear growth faltering is a reflection of chronic malnutrition as a result of failure to receive adequate nutrition over a long period and recurrent or chronic illness.

$$HAZ\ Score = \frac{(Observed\ value) - (Median\ \ reference\ value)}{Std\ deviation\ of\ \ referene\ \ population}$$

In a well-nourished population, there is a reference distribution of height for children under age 5. Under-nourishment in a population can be estimated by comparing children to a reference population. The reference population used in this study is based on the WHO growth standards. This growth reference is a single international reference that represents the best description of physiological growth for all children under 5 years of age all over the world which is taken from the multicenter growth reference study. The multicentre growth reference study carried out in two study design longitudinal study (birth to 24 months) and cross-sectional study (18 to 71 months aged children). Samples were pooled from six participating countries (Brazil, Ghana, India, Norway, Oman, and the United states). Total number of sampled children found was 8,500. For the selection of the study sites they mainly based on selection criteria. Primary selection criteria includes socioeconomic status, low altitude, low mobility, minimum 20% of mothers willing to follow feeding recommendations and existence of breastfeeding support system. Secondary criteria includes rate of hospital deliveries, sufficient number of eligible births and proper public health related behaviors in study population. After fulfilling all these criteria study selected those six countries to make one international growth reference for all the children aged under five years.

2.4.2 Determinants

The main determinants were extracted from the child and household file of the survey. It is merged further into single file and grouped into factors associated with the child, mother, household, and geographic location.

Mother factors: Mother factors included, mother's age at child birth, education and height of mother. Mother's age at birth is calculated by using the century month code (MOHP and New ERA, 2011). Mother's age is categorized here into three groups 15-24 year, 25-34 year and 35+ years. Mother's education is divided into three group, No education, having primary education and having secondary or higher education. Mother's height ranges from 134.3-182.8 centimeter. The mean of mother's height is 151 centimeter, and height of mother is further classified into two groups, less than or equals to 150 centimeter and greater than 150 centimeter.

Child factors: This included age, sex and size at birth of the child. Age of the child is categorized into 5 group (less than 1, 1, 2, 3, 4) year, mother's perception of baby's size at birth is classified into very large, larger than average, average, smaller than average and very small groups.

Household factors: Household wealth index was calculated as a score of household property such as having means of transport, durable goods, and other facilities in the household. Household index is divided into five categories and each household was assigned according to those categories. The below 40% of the households was referred to as the poorest and poorer households, the next 20% as the middleclass households, and the above 40% as rich and richest households.

Geographic factors: These factors include place of residence and sub-region of the country. Place of residence is categorized as urban and rural. Sub-region of the country is separated as Eastern mountain, Central mountain, Western mountain, Eastern hill, Central hill, Western hill, Mid Western hill, Far Western hill, Eastern terai, Central terai, Western terai, Mid Western terai and Far Western terai.

The path diagram of the study is shown in Figure 2.2.

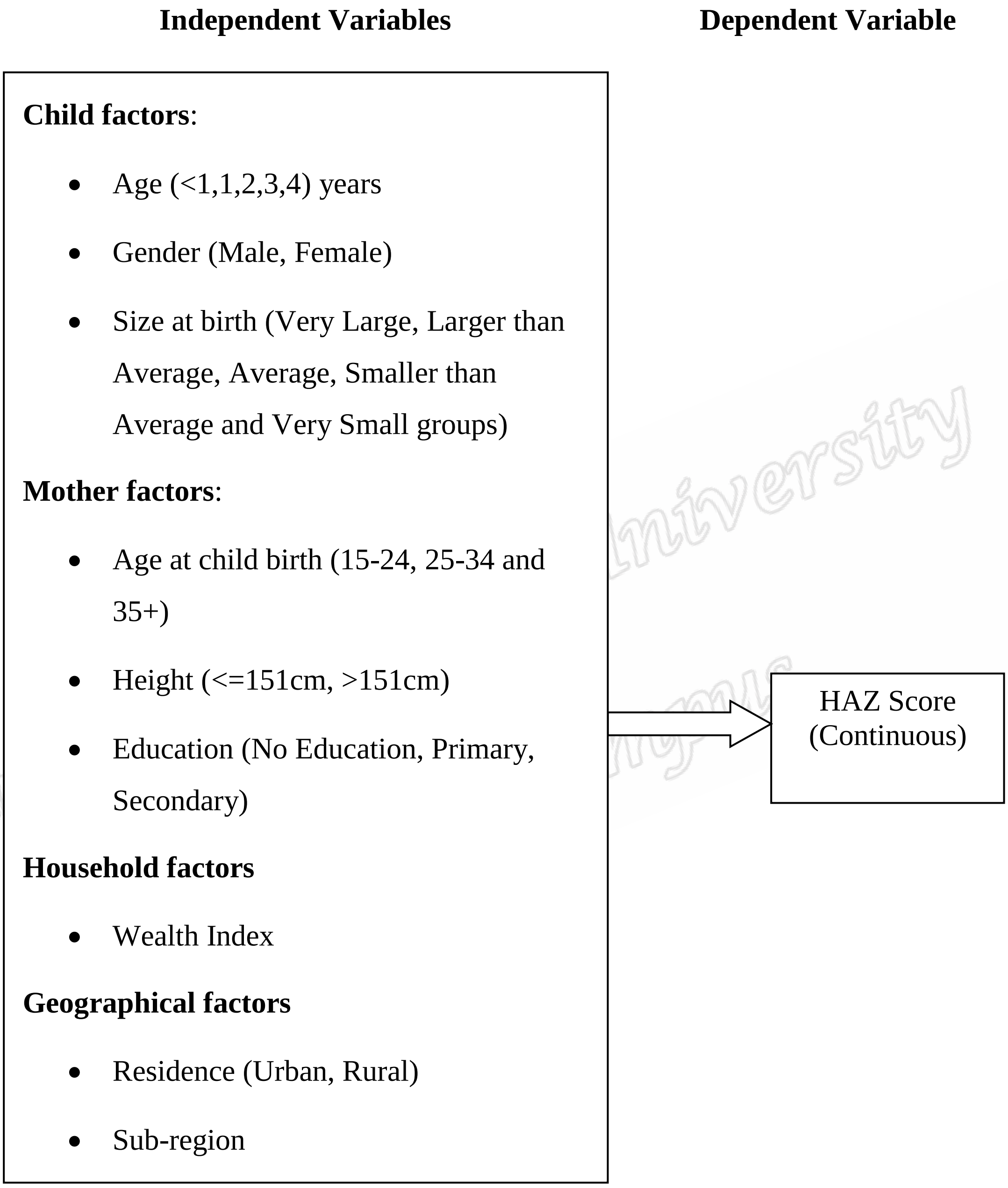

Figure 2.2: Path diagram of the variables

2.5 Statistical methods

The statistical methods comprise of methods for descriptive statistics, univariate analysis and statistical modeling.

2.5.1 Descriptive statistics

In preliminary analysis variables under the study are summarized by using frequency table, summary and box plot.

In the analysis of data where the outcome variable is continuous and the determinant is categorical, to compare the mean of HAZ score, variables having two categories such as gender of the child and place of residence were tested by using two sample t-test and variables having more than two groups such as age and size at birth of child, mother's age and education, household food security and sub-region were tested by using analysis of variance (ANOVA) test. Assumptions of two sample t-test and ANOVA are observation must be independent, distribution of data should be normal for each group and variances should be equal for each group.

Two sample t-test

The two sample t-test tests whether there are any significant differences between the means of two or less than two independent groups at population means are the same and the t-test statistic is obtained as follows:

$$t = \frac{\bar{y}_1 - \bar{y}_2}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}, \quad s = \sqrt{\frac{(n_1 - 1)s_1^{\ 2} + (n_2 - 1)s_2^{\ 2}}{n_1 + n_2 - 2}}$$

Where, $\bar{y}_1$ and $\bar{y}_2$ are sample means and n_1 and n_2 are sample size for each group. s_1 and s_2 denote the standard deviations of two groups respectively, s is the pooled standard deviation of the sample. A p-value is now obtainable from the table of the two tailed t distribution with $n_1 + n_2 - 2$ degrees of freedom.

One way Analysis of Variance (ANOVA)

The one way analysis of variance is used to determine whether there are any significant differences between the means of three or more independent groups. Analysis of variance is carried out by computing a statistic called the F statistic. Let suppose there are n_j observations in sample *j*, and the outcome is denoted by y_{ij}. Where, i= 1, 2,......, n_j and C is the number of categories within the independent variables.

Now, F statistics is defined as

$$F=\frac{(s_0-s_1)/(c-1)}{s_1/(n-c)}$$

Where

$$s_0=\sum_{j=1}^{c}\sum_{i=1}^{n_j}(y_{ij}-\bar{y})^2\ ,\ s_1=\sum_{j=1}^{c}\sum_{i=1}^{n_j}(y_{ij}-\bar{y}_j)^2$$

and,

$$\bar{y}_i=\frac{1}{n}\sum_{i=1}^{n_j}y_{ij}\quad ,\ \bar{y}=\frac{1}{n}\sum_{j=1}^{c}\sum_{i=1}^{nj}y_{ij}\ ,\qquad n=\sum_{j=1}^{c}n_j$$

2.5.2 Multiple linear regression

The association of all determinants with outcome variable was assessed in multiple linear regression model. Multiple linear regression model is a method for studying the relationship between a continuous dependent variable and more than two continuous as well as categorical independent variables. Multiple regression model equation takes the form,

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ..., \beta_n x_n + \varepsilon$$

Where, Y is outcome variable, β_0 is intercept and $\beta_1, \beta_2, \beta_3, ..., \beta_n$ are regression coefficients and ε is error term. Sum contrasts were used to compare and interpret the results (Tongkumchum and McNeil, 2009). After fitting the linear regression model, normality assumption of the residuals is required to check the model. Normal quantile quantile (q-q) plot is used to check the goodness of fit of the residuals. Normal q-q plot is a probability plot, which is a graphical method for comparing two probability distributions by plotting residuals against their theoretical quantiles. The linearity of the points suggests that the data are normally distributed. However the deviation from linearity with outliers suggests that data are not normally distributed. In order to make correction to the outliers, their characteristics need to identify either they are due to errors or not. Identifying those outliers was not due to any type of error they are considered as genuine outliers. Genuine outliers are typically treated in many ways. Among them we are using one method called winsorization. Winsorization is a process that involves bringing the outliers towards the specified value. The process consists of pulling the outliers closer to the specific value by subtracting some adjustment values (Gosh and Vogt, 2012). Adjustment values can choose from the q-q plot by looking at residuals deviation point. From which points the residual values starts to deviate the most we can choose as adjustment value as that point.

Chapter 3

Results

This chapter consists of preliminary results and final statistical results. In this chapter summary and frequency distributions of the variables are shown and then the associations between these variables are presented using t- test and ANOVA. Linear regression model was fitted to assess the association of all determinants with HAZ score.

3.1 Distributions of the variables

Distribution of height of the children according to their age in months is shown in the figure 3.1. From the figure we can see that the most of the children's height is in increasing trend with the increasing age.

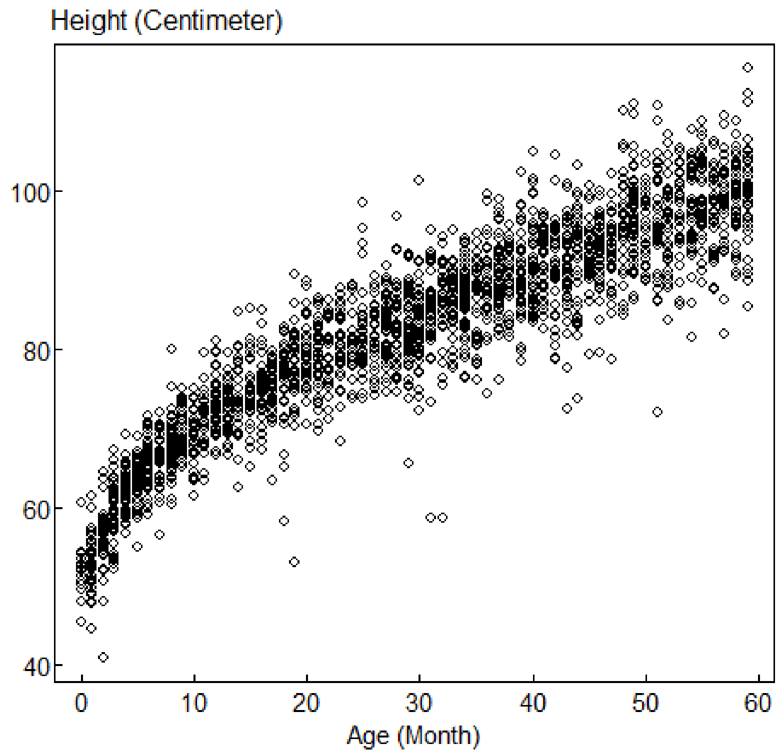

Figure 3.1: Distribution of height of the children according to the age

From the figure 3.1 we can see the pattern of height of the children with age. The height of children in centimeter and age of children in month is used further to calculate HAZ score of children.

The distribution of the HAZ score is presented here through boxplot. From the Figure 3.2. It is investigated that the outcome variable has two extreme values. Without omitting those extreme values mean and standard deviation of HAZ score of under 5 years Nepalese children was -1.69± 1.48, minimum is -9.71 and maximum is 16.27.

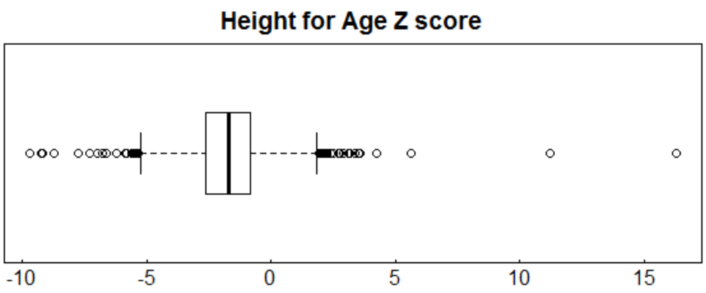

Figure 3.2: Distribution of HAZ scores

After investigating those extreme values, it was realized that they were due to data error and those two extreme values were omitted. By this process, this analysis was confined to 2,330 children. After removing the outlier the mean and standard deviation of HAZ score of Nepalese under 5 year children was found to be -1.73 ± 1.48, minimum value is -9.71 and maximum is 5.61.

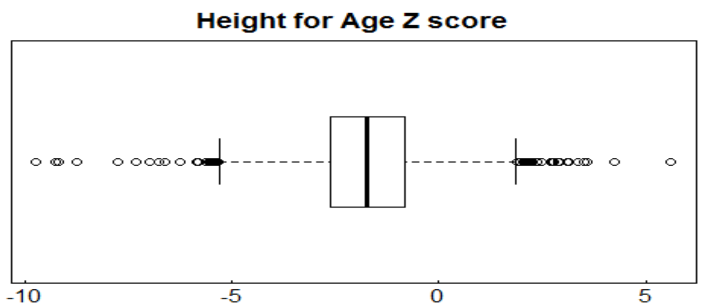

Figure 3.3: Distribution of HAZ Scores after omitting extreme values

Among 2,330 children, more than half of HAZ score has a negative value. The mean value of HAZ score of children was negative (-1.73). The negative value shows that the distribution of HAZ score was below the mean which signifies that in the majority of children, linear growth has been adversely affected.

The frequency distributions of demographic and socio-economic characteristics of the study sample are shown in Table 3.1. Among the total sample size of 2,330 children, a total of 1,210 (51.8%) boys and 1,120 (48.1%) girls aged less than 5 years were studied. Almost equal percentages of children (19-21%) were distributed among the all age group. For the children who, at birth, were perceived by their mothers, approximately 62% of children were of average size whereas 14% were smaller than average and 17% were larger than average. Children with their mother’s height >151 centimeter were 52%. More than half (56%) of the mother's were aged 15-24 years at delivery, and 8% of the mothers were aged above 35 years.

Fourty six percent of the total mothers had no formal education and among the educated group 19% had only primary education and one third (34%) had secondary and higher education. More than one fourth (30%) were from the poorest households according to their wealth index. The majority (80%) of children were from rural areas and almost equal ranges 5-9% of children were from each sub-region.

Table 3.1: Percentage distribution of children by their socio-demographic characteristics and geographic affiliation, Nepal Demographic Health Survey-2011 (n=2,330)

Determinants	Number (N=2,330)	percent
Sex of the child		
Male	1,210	51.88
Female	1,120	48.11
Age of the child		
less than 1 year	452	19.31
1 year	444	19.10
2 year	491	21.07
3 year	496	21.29
4 year	447	19.23
Child's size at birth (mother's recall)		
Very large	52	2.23
Larger than average	393	16.87
Average	1,447	62.02
Smaller than average	342	14.67
Very small	96	4.12
Mother's Height		

Determinants	Number (N=2,330)	percent
<=151 cm	1,117	47.93
>151 cm	1,213	52.06
Mother's age at child birth		
(15-24) years	1,306	56.05
(25-34) years	843	36.18
35+years	181	7.76
Mother's education		
No education	1,075	46.13
Primary	454	19.48
Secondary and higher	799	34.37
Wealth Index		
Poorest	715	30.68
Poorer	473	20.30
Poor	438	18.79
Richer	355	15.23
Richest	349	14.97
Place of residence		
Urban	472	20.32
Rural	1,858	79.67
Sub-region		
Eastern Mountain	147	6.30
Central Mountain	107	4.58
Western Mountain	194	8.31
Eastern Hill	190	8.15
Central Hill	151	6.48
Western Hill	177	7.60
Mid western Hill	217	9.31
Far western Hill	215	9.22
Eastern Terai	200	8.57
Central Terai	230	9.86
Western Terai	153	6.56
Mid westernTerai	210	9.04
Far western Terai	139	5.96

Table 3.2 presented the mean and 95% confidence interval for mean of children from each group by their socio demographic characteristics and geographic affiliation.

Table 3.2: Summary distribution of children by their socio-demographic characteristics and geographic affiliation, Nepal Demographic Health Survey-2011 (n=2,330)

Determinants	Mean	95% CI	P value
Sex of the child			<0.001
Male	-1.73	(-4.59, 1.14)	
Female	-1.66	(-4.84, 1.52)	
Age of the child			<0.001
<1 year	-0.66	(-4.25, 2.93)	
1 year	-1.58	(-4.55, 1.39)	
2 year	-2.08	(-4.76, 0.58)	
3 year	-2.14	(-4.51, 0.23)	
4 year	-1.91	(-4.34, 0.51)	
Child's size at birth (mother's recall)			<0.001
Very large	-1.31	(-3.81, 1.18)	
Larger than average	-1.50	(-4.53, 1.53)	
Average	-1.64	(-4.76, 1.47)	
Smaller than average	-2.01	(-4.54, 0.51)	
Very small	-2.26	(-5.12, 0.59)	
Mother's Height			<0.001
<=151 cm	-1.97	(-4.98, 1.03)	
>151 cm	-1.43	(-4.38, 1.51)	
Mother's age at child birth			<0.001
(15-24) years	-1.67	(-4.48, 1.13)	
(25-34) years	-1.66	(-5.01, 1.68)	
35+years	-1.95	(-4.90, 0.98)	
Mother's education			<0.001
No education	-2.03	(-4.82, 0.76)	
Primary	-1.76	(-4.57, 1.04)	
Secondary and higher	-1.20	(-4.38, 1.98)	
Wealth Index			<0.001
poorest	-2.17	(-4.93, 0.59)	
poorer	-1.90	(-4.79, 0.98)	
poor	-1.56	(-4.25, 1.13)	
richer	-1.25	(-4.45, 1.93)	
richest	-1.04	(-4.24, 2.16)	
Place of residence			<0.001
Urban	-1.14	(-4.54, 2.25)	
Rural	-1.83	(-4.69, 1.02)	
Sub-region			<0.001
Eastern Mountain	-1.72	(-4.32, 0.86)	
Central Mountain	-1.90	(-4.25, 0.45)	

Determinants	Mean	95% CI	P value
Western Mountain	-2.18	(-4.79, 0.42)	
Eastern Hill	-1.82	(-4.84, 1.19)	
Central Hill	-1.33	(-4.21, 1.54)	
Western Hill	-1.31	(-5.28, 2.65)	
Mid western Hill	-2.01	(-4.95, 0.92)	
Far western Hill	-2.12	(-4.66, 0.40)	
Eastern Terai	-1.31	(-3.95, 1.33)	
Central Terai	-1.60	(-4.85, 1.65)	
Western Terai	-1.71	(-4.77, 1.34)	
Mid western Terai	-1.55	(-4.77, 1.67)	
Far western Terai	-1.22	(-4.12, 1.67)	

It is seen from Table 3.2 that the mean height for age is lower in male than in female children across age groups. The same is lower in 2 and 3 year old children than other age groups. For the children who, at birth, were perceived by their mothers to be very small and small, the mean height for age shows lower value than other groups. The value for children from mother's who were below and equal to 151 centimeter is lower than who were from above 151 centimeter. The mean height for age to 35+ years mothers at birth is lower than other groups and the same value is lower in children from mothers having no education compared to other groups. For children from poorest and poorer homes, the mean height for age is lower than children from other groups. The mean height for age is lower in children from rural place of residence and Western Mountain, Far Western Hill, Mid Western Hill and Central Mountain.

3.2 Model fitting

Linear regression analysis was used to identify the strength of association between the determinants and the outcome. All the determinants, which were significant in the univariate analysis, were consequently included in the multiple linear regression model.

Table 3.3 demonstrates the results from full model. Table shows the coefficients, standard errors and P values for all the parameters obtained from multiple linear regression model assessing the association of all the determinants with linear growth based on sum contrasts. The advantage of using weighted sum contrasts is that it helps to compare each mean of the group to the overall mean. The model initially fitted includes all the determinants such as sex of the child, age of the child, child's size at birth (mother's recall), mother's height, mother’s age at child birth, mother's education, wealth index, place of residence and sub-region.

From the result it is seen that sex of the child and mother’s age at child birth doesn’t shows any association with linear growth (P value>0.05). Age of the child, Child's size at birth (mother's recall), Mother's Height, Mother's education, Wealth Index, Place of residence and Sub-region had associated with linear growth (P value <0.05).

Table 3.3: Coefficients, standard error and p-values from multiple linear regression model based on sum contrast

Characteristics	Coefficient	Standard error	P value
Sex of the child			
Male	-0.01	0.03	0.67
Female	0.01	0.03	0.67
Age of the child			
Less than 1 year	0.97	0.05	0.00
1 year	0.06	0.05	0.23
2 year	-0.38	0.05	0.00
3 year	-0.44	0.05	0.00
4 year	-0.21	0.05	0.00
Child's size at birth (mother's recall)			
Very large	0.41	0.15	0.00
Larger than average	0.21	0.07	0.00
Average	0.03	0.06	0.49
Smaller than average	-0.24	0.07	0.00
Very small	-0.42	0.11	0.00
Mother's Height			
<= mean height	-0.26	0.03	0.00
> mean height	0.26	0.03	0.00
Mother's age at child birth			
(15-24) years	-0.00	0.04	0.91
(25-34) years	-0.01	0.04	0.70
35+years	-0.01	0.04	0.70
Mother's education			
No education	-0.09	0.04	0.02
Primary	-0.04	0.05	0.27
Secondary and higher	0.14	0.05	0.00
Wealth Index			
Poorest	-0.28	0.06	0.00
Poorer	-0.14	0.06	0.01
Poor	0.04	0.06	0.39
Richer	0.16	0.06	0.00
Richest	0.20	0.08	0.00
Place of residence			
Urban	0.12	0.04	0.00
Rural	-0.12	0.04	0.00
Sub-region			
Eastern Mountain	0.03	0.10	0.73
Central Mountain	-0.06	0.12	0.56

Characteristics	Coefficient	Standard error	P value
Western Mountain	-0.31	0.09	0.00
Eastern Hill	-0.09	0.09	0.29
Central Hill	0.27	0.10	0.00
Western Hill	0.20	0.09	0.02
Mid western Hill	-0.11	0.09	0.19
Far western Hill	-0.23	0.09	0.00
Eastern Terai	0.19	0.09	0.02
Central Terai	0.06	0.08	0.49
Western Terai	-0.26	0.10	0.01
Mid western Terai	0.02	0.08	0.80
Far western Terai	0.29	0.11	0.00

A stepwise backward elimination method was applied to select the best model. Table 4.2 reports the coefficients, standard errors and P values for all the parameters obtained from multiple linear regression model assessing the association of determinants with linear growth. It is shown from the table that older children had a negative growth coefficient compared to younger children. This signifies older age of the children is negatively associated with linear growth. Perceived small child size at birth had greater negative coefficient compared to the other groups. It indicates that small size at birth negatively affects the linear growth. Non-educated mothers had a negative coefficient while educated mothers had a positive coefficient. This shows that children from non-educated mother are more likely to be negatively associated with linear growth. Similarly, children from poor households had negative coefficients compared to those from richer households. This suggests that children from poor household are more prone to be negatively associated with linear growth. Children from rural areas had a negative coefficient compared to those from urban areas. From this it is seen that children from rural area have negative association with linear growth. Children from the Western Mountain region had the highest negative coefficient followed by Western Terai and Far western Hill compared to other regions.

Table 3.4: Coefficients, standard error and P values from reduced multiple linear regression model based on sum contrast

Characteristic	Coefficient	Standard error	P value
Child's age			
Less than 1 year	0.98	0.05	0.00
1 year	0.06	0.05	0.23
2 year	-0.38	0.05	0.00
3 year	-0.44	0.05	0.00
4 year	-0.22	0.05	0.00
Size at birth			
Very large	0.41	0. 15	0.00
Larger than average	0.22	0.07	0.00
Average	0.04	0.05	0.49
Smaller than average	-0.24	0.07	0.00
Very small	-0.43	0.11	0.00
Mother's height			
<= mean height	-0.27	0.03	0.00
> mean height	0.27	0.03	0.00
Mother's education			
No education	-0.09	0.04	0.02
Primary school	-0.05	0.05	0.27
Secondary school and higher	0.15	0.05	0.00
Wealth index			
Poorest	-0.28	0.06	0.00
Poorer	-0.14	0.06	0.01
Poor	0.04	0.05	0.37
Richer	0.17	0.06	0.00
Richest	0.20	0.08	0.00
Place of residence			
Urban	0.13	0.04	0.00
Rural	-0.13	0.04	0.09
Region			
Eastern Mountain	0.04	0.10	0.72
Central Mountain	-0.06	0.12	0.56
Western Mountain	-0.32	0.09	0.00
Eastern Hill	-0.09	0.09	0.28
Central Hill	0.28	0.10	0.00
Western Hill	0.20	0.09	0.02

Characteristic	Coefficient	Standard error	P value
Mid western Hill	-0.11	0.09	0.19
Far western Hill	-0.24	0.09	0.00
Eastern Terai	0.20	0.09	0.02
Central Terai	0.06	0.09	0.48
Western Terai	-0.26	0.10	0.01
Mid westernTerai	0.02	0.09	0.79
Far western Terai	0.29	0.10	0.00

After the linear regression model was fitted, the normality assumption requires that residuals be normally distributed. This assumption was verified and assessed by plotting residuals against theoretical quantiles as shown on Figure 3.3. The normal q-q plot shows that the most of the residuals lie on the diagonal line except some values at the lower extremes of the distribution. At the lower extremes some unusual observations were observed. Their characteristics were observed and realized those were not due to data error. The r-squared of the model is also 27%. So in order to improve the goodness of fit of the data, winsorization method was used. Firstly adjusted value was chosen from the normal q-q plot. It seems that residuals started to deviate from linear pattern at point -3. Hence the adjustment value is considered as $(a = -3)$. For those unusual observations $(a = -3)$ is used as adjusted value and subtracted to all those extreme values. Then again multiple linear regression model was run with those winsorized value. Normal q-q plot was plotted. An effect of winsorization affects estimate of the parameters negligibly. The r- squared remains unchanged to around 27%. Normal q-q plot before and after winsorization are presented in the figure 3.4 and figure 3.5 respectively.

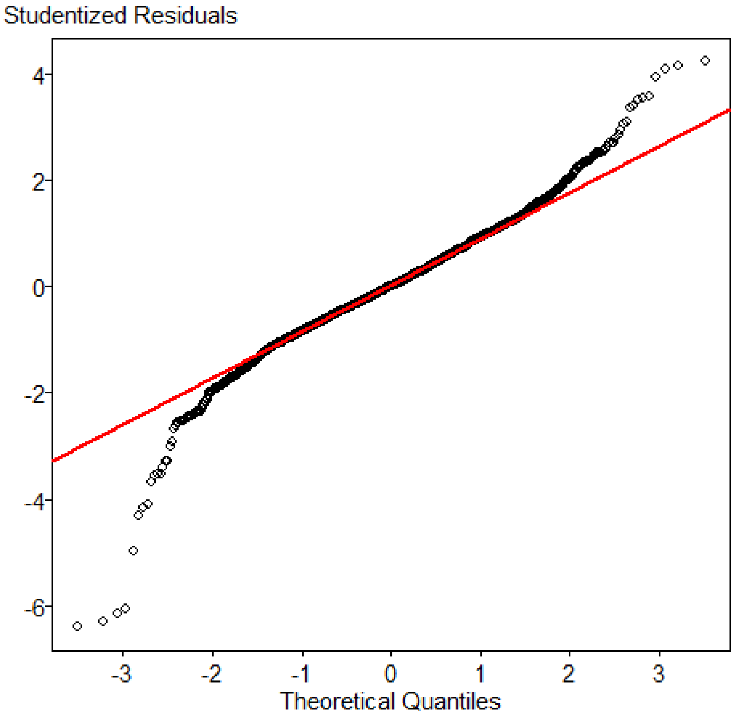

Figure 3.4: Normal scores plots of residuals from the linear regression model

Figure 3.4 shows the q-q plot showing most of the residuals lie on the diagonal line except some values at the lower extremes of the distribution.

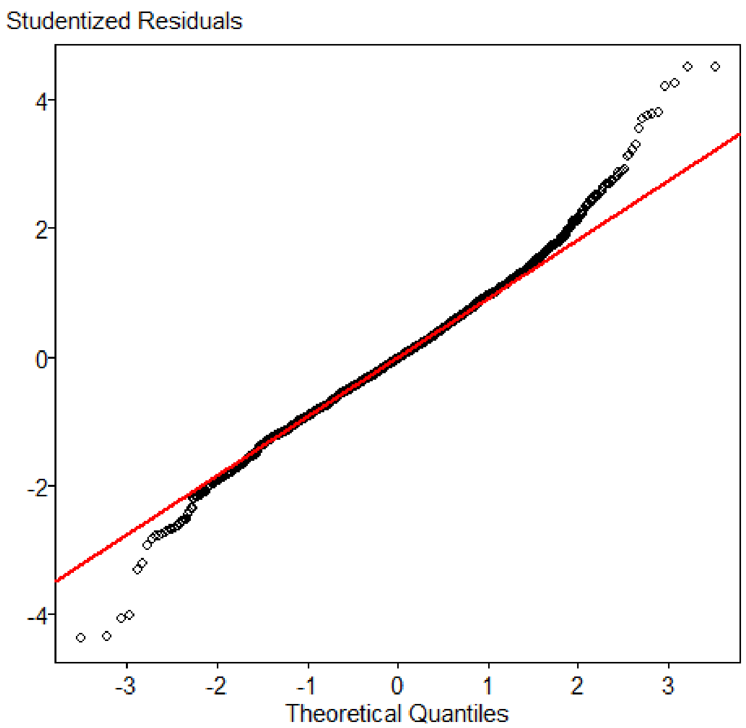

Figure 3.5: Normal scores plots of residuals from the linear regression model using winsorization

Figure 3.5 shows the q-q plot after winsorization method showing most of the residuals lie on the diagonal line. An effect of winsorization affects the estimate of the parameters negligibly and r- squared also remain unchanged. So the further results based on the multiple linear regression model before using winsorization method.

After verification of the model, 95% confidence interval, an interval surrounding an estimated population characteristics and which contains the population characteristics with probability 0.95 was calculated. An advantage of these confidence intervals is that they provide simple criterion for classifying levels of a factor into three groups according to whether each corresponding confidence interval exceeds, crosses or below the overall mean. Confidence intervals for these parameters were obtained by using the standard errors obtained through fitting each model.

The mean HAZ scores with corresponding 95% confidence intervals by age of child, children's size at birth, mother's height, mother's education, household wealth index, place of residence and region obtained from the model is presented in Figure 3.6. The horizontal line symbolizes the overall mean HAZ score.

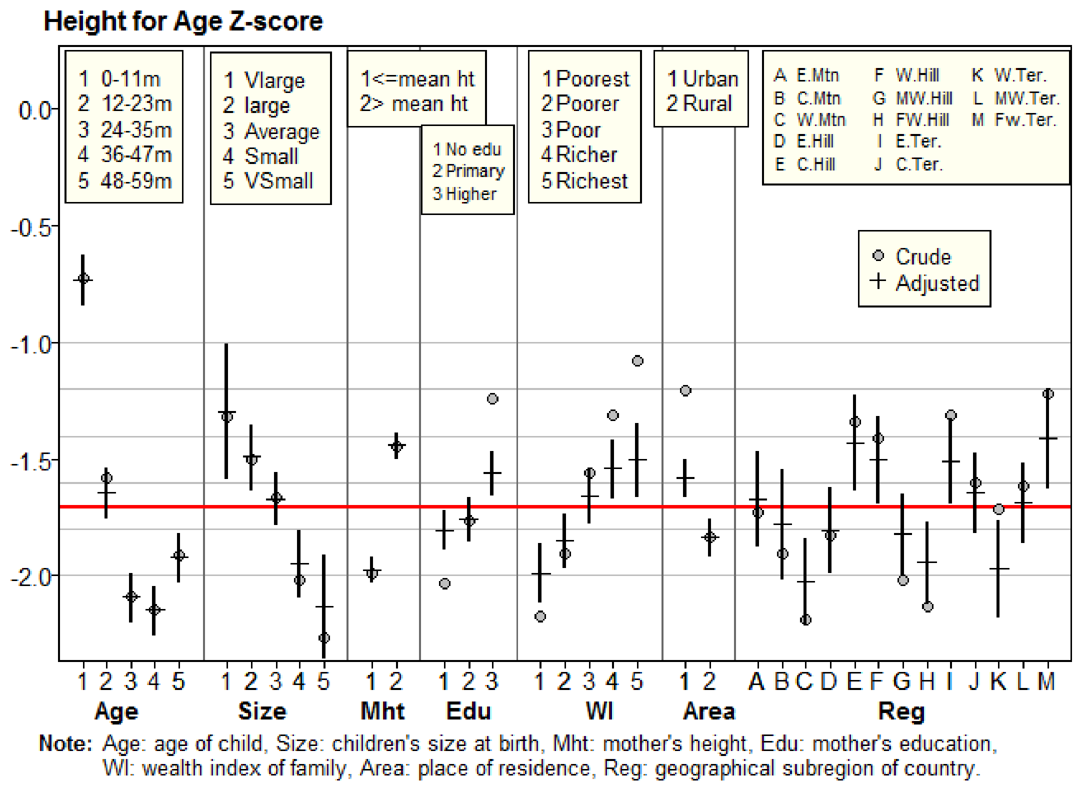

Figure 3.6: 95% confidence interval of linear growth of under five children in Nepal by associated variables

Children in age groups 24-35 months, 36-47 months and 48-59 months had significantly lower HAZ scores than the overall mean. Children who, at birth, were perceived by their mother to be small and very small or children whose mother was non-educated or children from poorer and poorest socioeconomic households had lower HAZ scores than the overall mean. Children from rural areas or from the

Western Mountain, Eastern Terai, Western Terai and the Far western Hill had lower HAZ score than the overall mean.

Chapter 4

Conclusions and Discussions

This chapter includes the discussions, conclusions, limitations and recommendation for further studies.

4.1 Conclusions and Discussions

Findings from this analysis indicate that the mean and standard deviation of HAZ score was -1.73± 1.48 (range -9.71 to 5.61). Individual characteristics such as age, size the of child at birth, household characteristics such as wealth index, mother's education , mother's height and geographic area including region and place of residence were associated with linear growth of children.

Study explored social demographic and geographic factors associated with linear growth of under five children in Nepal which were consistent with other studies (Tiwari *et al*., 2014). Children who, at birth, were perceived by their mother to be small, children from non-educated mother, from poor household and from rural areas were had negative linear growth. Faltered linear growth of children will have an adverse effect throughout their lives. Hence, appropriate interventions are required to prevent linear growth faltering among under five children in Nepal.

Discussions

Use of the mean HAZ score as an index of malnutrition in the children's population instead of using a cut off value (below -2SD) facilitates easier interpretation, i.e. if more than half of the children's linear growth is faltered, then an urgent intervention is needed for the whole community, not only for the growth faltered children.

This study explored the association of demographic and socio-economic factors with HAZ score among under five children in Nepal. Older aged children (age > 24-35 months) had a higher risk of linear growth falteration than those in the age group (0-23 months). A similar finding was reported in a recent study on linear growth faltering (Tiwari *et al*., 2014) in Nepal. A possible reason for this could be related to improper timing and variety of food during weaning (Khanal *et al*., 2013; Marquis *et al*., 1997). However, one study revealed that linear growth faltering will start from infancy, not only when the child is older (Espo *et al*., 2002). This difference might be due to differences in socio-economic conditions, geographic locations, breastfeeding and other health related practices (Khanal *et al*., 2013; Marquis *et al*.,1997; Rayhan and Khan, 2006).

Children who, at birth, were perceived by their mother to be small had negative linear growth and this result was supported by previous studies conducted in Bangladesh and Brazil (Rayhan and Khan, 2006; Vitolo *et al*., 2008). Non-educated mothers had children with negative linear growth and this result is al so consistent with the findings of a study from Bangladesh (Rayhan and Khan, 2006). Genetic factors of the mother such as height also had an impact on linear growth. Small height of the mother was also associated with negative linear growth which is similar to a finding from a study conducted in Thailand (Mongkolchati *et al*., 2010).

Children from poorer households had a negative linear growth. A possible explanation for this could be that 69% of Nepalese children are severely deprived of at least one basic necessity (sanitation, information, water, shelter, food, education, health) and 38% are severely deprived of one or more basic necessities, which is an indicator of poverty (UNICEF, 2010). Previous studies are consistent with the finding that lower socioeconomic status of the household is one of the causes for linear growth faltering in children (Hien and Hoa, 2009; Vitolo *et al*., 2008; Zottarelli *et al*., 2007; Egata *et al*., 2010).

Children from the Western Mountain region had lower HAZ scores. This result has a probable association with Hunger Index scores in those sub-regions of Nepal. Hunger Index scores of children from the Far Western and the Mid Western Mountain regions are very high in comparison to the national average (Hollema and Bishokarma, 2009). A similar result was seen in a previous study that there is a geographical inequality in children's nutritional status (Cesarea *et al*., 2015; Rader *et al*., 2012).

4.2 Limitations and Recommendations

This study had some limitations. Study used secondary data so most of the information was limited. Some of the causes which have direct impact on linear growth like nutrition and complementary food availability, infection and other contextual factors such as sociopolitical instability, Health and health care, water sanitation and environment were left behind in this study. Study only explore the determinants but unable to explain the further association with determinants.

Further study is needed to explore more specific factors such diet related factors and clinical factors affecting the nutritional status of under five year children. Nutrition program focusing the child should be propelled along with behavioral change communication.

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Appendix

Certificate of Appreciation

This is to certify that

Sumitra Kattel

has presented an academic paper at

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Mahidol University, Salaya Campus, Thailand

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Head of Department of Society and Health
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Determinants of Linear Growth among Children Aged under 5 in Nepal

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Abstract

Linear growth of children is an important indicator to assess the nutritional status of the population. Once the linear growth of children is faltered, it is irreversible. Linear growth faltering among under 5 years children is a major public health problem in Nepal with the prevalence of 41 percent. The objective of this study is to explore the determinants associated with linear growth among under five years Nepalese children using data from Nepal Demographic Health Survey 2011. Height for Age Z (HAZ) score, which is one of the anthropometric indicators, shows the linear growth of the children. We examine the HAZ score of 2,332 children from Nepal Demographic Health Survey 2011. Multiple linear regression model was used to explore the association between possible determinants and the linear growth. The mean and standard deviation of linear growth of Nepalese children under 5 year was found to be -1.73 ± 1.48. Mean HAZ score in children from different age groups, residing in various sub-regions, from varied socioeconomic group and mothers having different educational status, different height, children from different geographical area and also place of residence were found significantly different compared to overall mean of HAZ score. In conclusion, increasing age of children, children from illiterate mother, children from poorest household and children from rural area were found negatively associated with linear growth compared to overall mean of the Nepalese children.

Key words: Anthropometric measurement, height for Age Z (HAZ) score, linear growth, under 5 year children, Nepal

Introduction

Linear growth of children has been considered as the best indicator of good health (Onis et al., 2004). Growth is understood as one of the important indicators of malnutrition globally (Onis et al., 2000). Malnutrition is the condition where the body goes into irreversible damage with serious mental impairment (Rice etal., 2000). It signifies fragile nutritional status of the body which includes both over- and under-nutrition.

Growth assessment is a strong means for evaluating the health and nutritional status of children. There are various measures for calculating the anthropometric indices. Among them, height for age z (HAZ) score, weight-for-height z (WHZ) score and weight-for-age z (WAZ) score provides the comprehensive description of growth. HAZ score reflects linear growth, WHZ reflects body proportion, and WAZ represents combination of both linear growth and body proportion (Onis et al., 1993; Onis and Blossner, 1997).

Among above mentioned anthropometric indices, this study focuses only on HAZ score. Linear growth is the growth of a child in a linear scale and linear growth faltering is the growth deficit in the child. This linear growth deficit reflects the long term malnutrition in the population. HAZ score below -2 standard deviation indicates long-term growth faltering which is also called stunting. Linear growth faltering is one of the serious indicators of malnutrition.

Malnutrition remains as a major public health problem globally and locally. Under-nutrition in childhood is one of the leading contributors to childhood morbidity and mortality in the whole world (Egata et al., 2013; Rice et al.,2000). In developing countries, malnutrition is synonymous to under-nutrition (WFP, 2005). Studies from many developing countries revealed that one third of all children under 5 years of age are found stunted in developing countries, and 70% of those children found in Asia, especially in the South central Asia (Onis et al., 2000). In Nepal, prevalence of stunting seems in a decreasing trend, from 50% in 2001 to 41% in 2011. Though it is not a significant reduction, and severity of linear growth faltering among the children in some parts of the country is higher in comparison with the national average (MOHP, 2011). In addition, Nepal has almost reached towards the goal to achieve the Millennium Development Goal target for child mortality. On the other hand, target for infant mortality is still far and is found that malnutrition is one of the key obstacles to accomplish the target (Malla et al., 2011).

It is possible that childhood infections and unsatisfactory feeding practices, or mostly both of them, are major factors affecting the physical and mental growth of children (Onis et al., 2000). Various studies were conducted on factors associated with and prevalence of linear growth faltering (stunting) in developing countries (Espo et al., 2002; Rayhan and Khan, 2006; Tiwari et al., 2014). However in this study we are using HAZ score as an outcome of the study in a continuous measure to explore the factors associated with linear growth of under 5 year children in Nepal.

Literature review

Many studies throughout the world were concerned about factors affecting the linear growth faltering. Related literatures applicable to this paper were reviewed under following different subheading.

<u>Prevalence of linear growth faltering (stunting) and its severity</u>

Asia and Africa have a burden of 90% of the developing world's growth faltered children. Prevalence of growth faltered children has reduced from 47% in 1980 to about 33% in 2000 in developing countries. However, increasing number of under-five population results in an increase in the number of growth faltered children and linear growth faltering is still remaining as a public health problem in developing countries (Onis et al., 2000). Nepal was ranked among the top 20 countries with the highest burden of linear growth faltering among under 5 years children worldwide (UNICEF., 2009).

<u>Factors affecting the linear growth faltering</u>

The study conducted in Nepal reported that household wealth index, perceived size of baby at birth, and breastfeeding for more than 12 months were the factors which have effect on linear growth faltering (Tiwari et al., 2014). Another study conducted in

Nepal suggested that mother education and wealth index are very important factors associated with the nutrition of children in Nepal (Crum et al., 2012). According to Cesarea et al. (2015), it shows that there is a significant association between geographical inequalities in children's nutritional status. Mother having only primary education, lowest wealth group and small height is shown to be significantly associated with linear growth faltering in the study done in Thailand (Monglkochati et al. (2010).

Methodology

Data Source

In this study, data were obtained from Nepal Demographic Health Survey 2011. It was a two-stage stratified clustered sampling design in which, at the first stage 289 primary sampling units were selected on the basis of probability proportionate to size and in the second stage a total 10,876 households were selected randomly. Of the total, every second household was selected as a sub sample for anthropometric measurement of under 5 years children. The sample size included total 2,392 children under 5 years of age from selected subsample of 1,780 household. Among them 59 children were excluded. The reason for exclusion is; some were not present at the time of measurement and some of their mother refused to take child's measurement which gives in total 32 children and remaining 27were from multiple births. Multiple births were excluded from the study on the basis that multiple births affect linear growth faltering (Mbuya et al., 2010). Data from one child is discarded during the calculation of HAZ score from WHO anthro which is flagged as outliers according to the valid ranges accepted by WHO ($-6<HAZ<6$). So the final sample size became 2,332 children.

Measurement of variables

HAZ score

Linear growth is measured by adjusting the height of children with age i.e. HAZ score. Calculation of HAZ score from WHO Anthro has been described elsewhere (WHO, 2006). Based on the definition provided by the WHO, HAZ score conveys a child’s height in terms of the number of standard deviations above or below the median height of healthy children from a reference group. Reference group used for measuring the growth has been described elsewhere (Onis et al., 2004).

Determinants

The main possible determinants of interest were selected all from the survey and extracted from the child and household file of the survey and merged into single file. These were grouped naturally into factors associated with the child, mother, household, and geographic location within Nepal. Household food security is calculated from the seven variables providing each variable option with one score and adding all the scores of them. After that, the score 0 was coded as secure, 1-2 mild secure, 3-10 moderate secure and more than 10 as severe insecure (Tiwari et al., 2011) and household wealth index was calculated as a score of household property such as having means of transport, durable goods, and other facilities in the household. By this, we calculated household index which further divided into five categories and each household was assigned according to those categories. The below 40% of the households was referred to as the poorest and poorer households, the next 20% as the middleclass households, and the above 40% as rich and richest households.

Statistical methods

Since the outcome variable is continuous; to compare the mean, variables having less than two categories were tested by using t-test while more than two groups were tested by using Analysis of variance (ANOVA) test. The association of all determinants with outcome variable was assessed in multiple linear regression model by using stepwise backward selection method for the selection of best model. To check the normality assumption of the model, normal score plot was plotted.We used sum contrast in final model because treatment contrasts is based on the reference group and each determinant does not comprise a control or reference group and the use of sum contrast gives a measure of difference for each level of each determinant factor from the overall mean of the outcome (Tongkumchum and McNeil, 2009). The statistical software system R version 3.1.1 was used for managing and analyzing all data (R Core Team, 2012).

Results

<u>Distribution of variables</u>

Table 1 shows equal proportion of sex ratio (52% male and 48% female) and approximately equal distribution of children for each year and age group ranging from 19-21%. The mean age in month of the children is 29 months. On the basis of mother's perception on the size of child at birth, 17% of the babies were larger and 14% were smaller than average whereas 62% of children were of average size. In case of place of residence, majority (80%) of children lived in rural areas. Mean height of mother was 151 cm and 48 % of mothers were below or equal to the mother's mean height. Among the mothers interviewed, the proportion of illiterate mothers (who couldn't even read a sentence) was 46%. Eight percent of the mothers were found above 35 years at the time of their child birth. Many children (30%) were from poorest household economy. Also15 % of the households reported food severe insecurity. Almost equal (4-9%) percentages of children were selected from each sub-region.

Table 1: Percentage distribution of children by their socio-demographic characteristics and geographic affiliation, Nepal Demographic Health Survey-2011 (n=2,332)

Determinants	Count	percent
Sex of the child		
male	1,210	51.88
female	1,122	48.11
Age of the child		
less than 1 year	450	19.31
1 year	445	19.10
2 year	491	21.07
3 year	496	21.29
4 year	448	19.23
Child's size at birth (mother's recall)		
Very large	52	2.23
Larger than average	393	16.87
Average	1,449	62.02
smaller than average	342	14.67
very small	96	4.12
Mother's Height		
<=151 cm	1,117	47.93
>151 cm	1,213	52.06

Determinants	Count	percent
Mother's age at child birth		
(15-24) years	1,306	56.05
(25-34) years	845	36.18
35+years	181	7.76
Mother's education		
Illiterate	1,075	46.13
Primary	454	19.48
Secondary and higher	801	34.37
Wealth Index		
poorest	715	30.68
poorer	473	20.30
poor	438	18.79
richer	356	15.23
richest	350	14.97
Household food security		
secure	923	39.52
mild insecure	147	6.30
moderate insecure	909	39.01
severe insecure	353	15.15
Place of residence		
Urban	474	20.32
Rural	1,858	79.67
Sub-region		
Eastern Mountain	147	6.30
Central Mountain	107	4.58
Western Mountain	194	8.31
Eastern Hill	190	8.15
Central Hill	151	6.48
Western Hill	178	7.60
Mid western Hill	217	9.31
Far western Hill	215	9.22
Eastern Terai	200	8.57
Central Terai	230	9.86
Western Terai	153	6.56
Mid westernTerai	211	9.04
Far western Terai	139	5.96

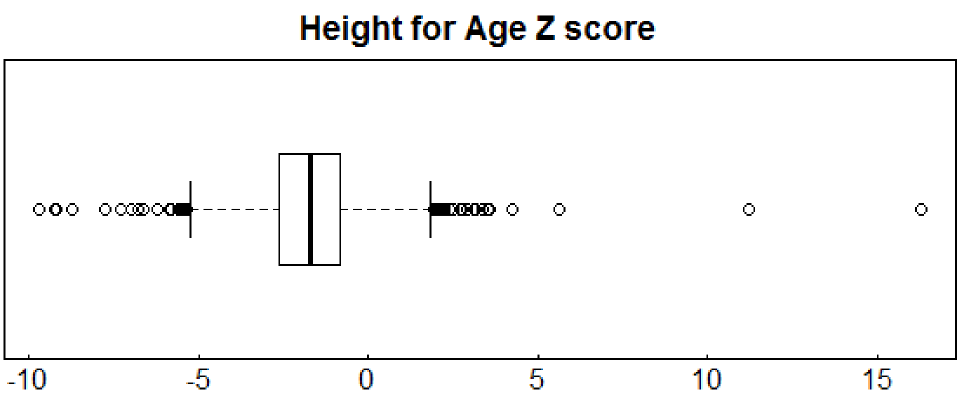

Figure 1: Height for Age Z score of the children (NDHS 2011)

Figure 1 shows the distribution of HAZ score. It shows two outliers which were investigated further and omitted by realizing the data error. By this our further analysis remains on 2,330 children. After removing the outlier the mean and standard deviation of HAZ score of Nepalese under 5 year children was found to be -1.73 ± 1.48, minimum value is -9.71 and maximum is 5.61. Among 2,330 children, more than half of HAZ score has a negative value.

The association between HAZ score and all determinants were tested by using t-test and ANOVA test. Place of residence, gender of child, age group of the child, child's size at birth on mother's perception, mother's age at child birth, mother's education, mother's height, wealth index, household food security and sub regions were significantly associated (p-value <0.05) with linear growth.

Table 2 presents the coefficients, standard errors and p-values for all the parameters obtained from multiple linear regression model fitted between variables and linear growth.

It is shown from the table that the increasing age of child is negatively associated with linear growth. Despite average sized mother at the time of perception, children's' growth at their birth is not associated with linear growth however who were smaller than average at their birth were negatively associated with linear growth. Children from Rural areas of residence were negatively associated with linear growth. Similarly children from poorest household are negatively associated with linear growth. Mothers who can't read were negatively associated whereas mothers having higher education is positively associated with linear growth. Children from Western Terai, Far western Hill and Western Mountain were negatively associated with linear growth.

Table 2: Statistical Model Result, Nepal Demographic Health Survey- 2011

Characteristics	Coefficient	Standard error	P value	
Child age				
0-11 months	0.977	0.054	0.0000	***
12-23 months	0.064	0.054	0.2317	
24-35 months	-0.385	0.052	0.0000	***
36-47 months	-0.441	0.052	0.0000	
48-59 months	-0.215	0.054	0.0000	
Mother's height				
<= 151 cm	-0.265	0.027	0.0000	
>151 cm	0.265	0.027	0.0000	***
Child's size at birth (mother's perception)				
Very large	0.410	0. 146	0.0049	**
Larger than average	0.216	0.070	0.0019	**
Average	0.038	0.055	0.4916	
smaller than average	-0.239	0.072	0.0009	***
very small	-0.425	0.112	0.0001	***
Subregion				
Eastern Mountain	0.036	0.102	0.7238	
Central Mountain	-0.068	0.119	0.5647	
Western Mountain	-0.319	0.093	0.0006	***
Eastern Hill	-0.098	0.091	0.2856	
Central Hill	0.278	0.101	0.0059	**
Western Hill	0.206	0.093	0.0270	*
Mid western Hill	-0.114	0.087	0.1927	
Far western Hill	-0.236	0.088	0.0075	**
Eastern Terai	0.200	0.090	0.0268	*
Central Terai	0.060	0.086	0.4881	
Western Terai	-0.260	0.103	0.0116	*
Mid westernTerai	0.022	0.086	0.7977	
Far western Terai	0.294	0.106	0.0055	**
Place of residence				
Urban	0.128	0.038	0.0009	***
Rural	-0.128	0.038	0.0009	***
wealth status				
poorest	-0.279	0.062	0.0000	***
poorer	-0.141	0.059	0.0166	*
poor	0.049	0.056	0.3799	
richer	0.168	0.062	0.0073	**
richest	0.203	0.078	0.0093	**
Mother's education				
Illiterate	-0.097	0.042	0.0222	*
Primary	-0.050	0.045	0.2723	

Characteristics	Coefficient	Standard error	P value	
Secondary	0.147	0.046	0.0016	**

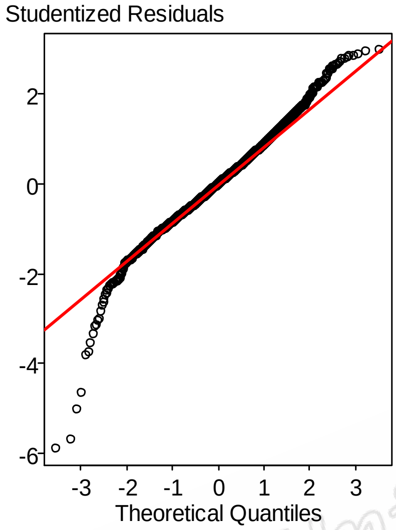

Figure: 2 Normal score residual plot from the model

Figure 2, shows normal scores plot of residuals from the linear regression model with two high outliers omitted. Most of the HAZ values lie on the diagonal line except some values which lies below the diagonal line.

Conclusion and Discussion

It is seen from the study that increasing age of children is associated with linear growth, as the age of the child increases, it shows negative association with linear growth. Similar results were seen from the study on linear growth faltering done by Tiwari et al., (2011). Cause for the association of increasing age of child with linear growth might be: improper timing and varieties at the period of weaning (Khanal et al., 2013; Marquis et al.,1997). In contrary to this result, study done by Espo et al. (2002) revealed that linear growth faltering is persistent throughout the infancy; not only in later age. This conflicting result may be due to the different socioeconomic conditions, geographic variation and breastfeeding practice of mother as well as various differences in practice. Children who were considered as small by their mother at birth were negatively associated with linear growth. This was consistent with the findings of other studies done in Bangladesh and Brazil (Rayhan and Khan, 2006; Vitolo et al., 2008). Children from mothers who could not read were negatively associated with linear growth, and this is supported by a previous study on linear growth faltering (Rayhan and Khan, 2006).

Household wealth index is also significantly associated with linear growth, children from poorer and poorest household were found negatively associated. Previous studies also supports that lower socioeconomic status of the household is one of the cause for linear growth faltering in children (Mahgoub et al., 2006; Hien and Hoa, 2009;Vitolo et al., 2008; Zottarelli et al., 2007; Egata et al., 2010).

Our study has some limitations. Since the outcome variable is continuous, multiple linear regression model is appropriate however with the assumption of some level of correlation among the children from the same cluster, we shall further use generalized estimating equation model to handle the co-relation.

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