GENERALIZED ESTIMATING EQUATION MODELS FOR GROWTH PATTERN OF HILLTRIBE AND LOWLAND CHILDREN AGED UNDER 18 MONTHS IN MAE CHAN DISTRICT, CHIANG RAI PROVINCE, THAILAND

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ABSTRACT

Etiologic factors related to newborn characteristics and growth in early childhood accumulate over a lifetime and are involved in many chronic diseases such as obesity, coronary heart disease and respiratory disease. Therefore, the purposes of this study were to construct Generalized Estimating Equation (GEE) models for growth patterns of hilltribe and lowland children aged under 18 months in Mae Chan District, Chiang Rai Province, Thailand. Additionally, the factors that affected growth patterns were identified. A longitudinal retrospective cohort of children who were born in Mae Chan Hospital during January 1, 2001 to December 31, 2004 was recruited. The individuals were routinely measured repeatedly from a routine immunization schedule over an 18 month period. The sample consisted of 1,028 children, 715 lowland and 313 hilltribe children. Weight for age, length for age, head circumference for age, ponderal index, and overall growth index were indices of child growth in this study.

The results showed that growth compared between hilltribe and lowland children was not different. Weight for age, length for age, head circumference for age, and ponderal index decreased over time, whereas the overall growth index increased as the children grew. Furthermore, birth weight, birth length, birth head circumference positively correlated to weight for age, while pregnancy order negatively correlated to weight for age. Birth weight positively correlated to length for age, while pregnancy order negatively correlated to length for age. Birth weight, birth head circumference and cesarean section positively correlated to head circumference for age. Maternal HIV status and children order correlated to ponderal index. Lastly, being male, birth weight, and birth circumference correlated to the overall growth index. In summary, the factors correlated to children’s growth that were found in this study were gender, birth weight, birth length, birth head circumference, pregnancy order, children order, delivery method, and maternal HIV status.

However, other studies have indicated other factors related to growth in children e.g. pre-birth factors, type of milk intake (breast or formula milk), food and nutrition intake, length and pre-pregnancy weight of mother, parental size, maternal education and occupation, HIV status of children born to HIV-infected mothers, illness or disease, etc. These factors should be further studied to explain child growth in similar populations.

KEY WORDS: GENERALIZED ESTIMATING EQUATION / GEE / LONGITUDINAL RETROSPECTIVE COHORT STUDY / GROWTH PATTERN / LOWLAND CHILDREN / HILLTRIBE CHILDREN

170P.

การใช้ GENERALIZED ESTIMATING EQUATION MODELS เพื่อศึกษาการเจริญเติบโตของเด็กชาวเขาและเด็กพื้นราบอายุต่ำกว่า 18 เดือนในอำเภอแม่จัน จังหวัดเชียงราย ประเทศไทย (GENERALIZED ESTIMATING EQUATION MODELS FOR GROWTH PATTERN OF HILLTRIBE AND LOWLAND CHILDREN AGED UNDER 18 MONTHS IN MAE CHAN DISTRICT, CHIANG RAI PROVINCE, THAILAND)

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บทคัดย่อ

โรคเรื้อรังที่เกิดขึ้นในช่วงชีวิตของคนเรา เช่น โรคอ้วน โรคหลอดเลือดหัวใจ และโรคทางเดินหายใจ มีสาเหตุส่วนหนึ่งมาจากลักษณะเมื่อแรกคลอดและการเจริญเติบโตในวัยเด็ก ดัชนีชี้วัดการเจริญเติบโตในเด็กนั้นมีหลายตัวซึ่งในการศึกษานี้ได้ใช้น้ำหนักตามอายุ (Weight for Age) ความยาวลำตัวตามอายุ (Length for Age) ความยาวรอบศีรษะตามอายุ (Head Circumference for Age) Ponderal Index และ Overall Growth Index วัตถุประสงค์ของการศึกษานี้เพื่อสร้างโมเดลการเจริญเติบโตของเด็กชาวเขาและพื้นราบ อายุต่ำกว่า 18 เดือนในอำเภอแม่จัน จังหวัดเชียงราย ประเทศไทย โดยใช้การวิเคราะห์โมเดลด้วย Generalized Estimating Equation (GEE) และระบุปัจจัยที่มีผลต่อการเจริญเติบโตนั้น ซึ่งการศึกษานี้เป็นการติดตามแบบระยะยาว ด้วยการเก็บข้อมูลย้อนหลังในเด็กที่คลอดในโรงพยาบาลแม่จัน ระหว่างวันที่ 1 มกราคม 2544 ถึงวันที่ 31 ธันวาคม 2547 โดยจะเก็บข้อมูลจากเด็กแต่ละคนที่มาชั่งน้ำหนัก วัดความยาวลำตัวและความยาวรอบศีรษะในช่วงแรกคลอดจนถึงอายุ 18 เดือนตามตารางการรับวัคซีน จำนวนตัวอย่างที่ได้ คือเด็กทั้งหมดจำนวน 1,028 คน ซึ่งเป็นเด็กพื้นราบ 715 คนและเด็กชาวเขา 313 คน

จากผลการวิเคราะห์ด้วย Multivariate GEE Analysis พบว่าการเจริญเติบโตของเด็กชาวเขาและพื้นราบไม่แตกต่างกัน ส่วนน้ำหนักตามอายุ ความยาวลำตัวตามอายุ ความยาวรอบศีรษะตามอายุและ Ponderal Index จะลดลงตามอายุที่เพิ่มขึ้น ในขณะที่ Overall Growth Index จะเพิ่มขึ้นเมื่ออายุเพิ่มขึ้น นอกจากนั้นยังพบว่าปัจจัยที่มีผลต่อการเปลี่ยนแปลงน้ำหนักตามอายุ ได้แก่ น้ำหนักแรกคลอด ความยาวลำตัวแรกคลอด ความยาวรอบศีรษะแรกคลอดและลำดับการตั้งครรภ์ สำหรับน้ำหนักแรกคลอดและลำดับการตั้งครรภ์ยังมีผลต่อความยาวลำตัวตามอายุอีกด้วย ส่วนปัจจัยที่มีผลต่อความยาวรอบศีรษะตามอายุได้แก่ น้ำหนักแรกคลอด ความยาวรอบศีรษะแรกคลอดและวิธีการคลอด ปัจจัยที่มีผลต่อการเปลี่ยนแปลงของ ponderal index ได้แก่ ลำดับบุตรและสถานภาพเอชไอวีของแม่ นอกจากนั้นเพศของเด็ก น้ำหนักแรกคลอดและความรอบศีรษะแรกคลอดยังมีผลต่อการเปลี่ยนแปลงของ overall growth index ด้วย สรุปได้ว่าปัจจัยที่มีผลต่อการเจริญเติบโตของเด็กที่พบ ในการศึกษานี้ได้แก่ เพศของเด็ก น้ำหนักแรกคลอด ความยาวลำตัวแรกคลอด ความยาวรอบศีรษะแรกคลอด ลำดับการตั้งครรภ์ ลำดับบุตร วิธีการคลอดและสถานภาพเอชไอวีของแม่

อย่างไรก็ตามจากการศึกษาอื่นๆ ได้พบว่ายังมีปัจจัยอื่นที่ส่งผลถึงการเจริญเติบโตของเด็ก ได้แก่ ปัจจัยก่อนคลอด การดื่มนมแม่หรือนมผสม การรับประทานอาหารหรือสารอาหารที่ได้รับ ความสูงและน้ำหนักก่อนตั้งครรภ์ของแม่ ขนาดตัวของพ่อแม่ การศึกษาและอาชีพของพ่อแม่ สถานภาพเอชไอวีของเด็กที่คลอดจากแม่ที่ติดเชื้อเอชไอวี ความผิดปกติหรืออาการเจ็บป่วยของเด็กขณะเจริญเติบโต เป็นต้น หากการศึกษาต่อไปในอนาคตสามารถรวมเอาปัจจัยต่างๆ ดังกล่าวเพื่อสร้างโมเดลการเจริญเติบโตของเด็ก ก็อาจจะอธิบายได้ชัดเจนมากขึ้น

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CHAPTER I
INTRODUCTION

1.1. Rationale and Justification

There are some reasons to believe that the etiologic factors for many chronic diseases accumulate over a person's entire lifetime, and those factors related to newborn characteristics and growth in early childhood. During growth, the human body increases in size and changes its proportions of various components due to hormone mediators. Growth is a complex, biological process regulated by multiple factors, which included genetics, nutritional intake, physical activity, age, gender, and endocrine balance. These factors are influenced a child's length and body composition during the growth years. Understanding of body composition and factors influencing its development can improve the prediction of adult status and help to create strategies for reducing the risk factors of various diseases. Anthropometry is an inexpensive, non-invasive method of assessing the size, shape and composition of the human body. Body size is an important index for children growth. Most widely used anthropometric measurements of body size are weight, length (measured in infants and children aged less than 2 years)/ height (measured in older children and adults), and head circumference. These measurements assess to a physical child's growth. The growth indices usually calculated from two or more raw anthropometric measurements, such as weigh for age, height for age, head circumference for age, weight for height, body mass index, and ponderal index (Gibson, 2005). Newborn infants may be small because they have suffered retarded growth in utero and/or because they are born preterm; in addition, there are also individual differences in size among newborns who are neither growth-retarded nor preterm (Morris, 1998). Further, body height is a good indicator of childhood living conditions. The adult height attainment is determined in part of factors acting affected during pregnancy, infancy, and childhood. Environmental factors, such as social class, parental education, maternal smoking during pregnancy, prenatal and postnatal growth have all been related to height (Gigante, 2006). Further, during infancy the measurement and interpretation of head circumference has an important place in screening for conditions in which head size is abnormal, e.g. hydrocephalus and microcephaly. This measurement is less important during childhood and adolescence, but it is relevant to the extended observation of children whose head circumferences were unusual during infancy.

There is considerable evidence that body size in early life, particularly weight at birth, is related inversely to chronic disease lately. Adult weight and height influenced by factors acting during pregnancy, infancy, and childhood, the association among weight, height and mortality is consistent with the effects of early life factors on morbidity and mortality in adulthood. Infancy is a period of rapid growth in body size. The very rapid intrauterine growth almost stops just before birth, and many full-term infants will lose some weights shortly after birth. Proper growth monitoring consists of serial assessments of both weight and length measurements over time so that growth velocity can be assessed. Accurate and reliable measurements are necessary to assess the growth status of an infant. High birth weight has been associated with overweight and obesity in children, adolescents, and adults. Likewise, infants of high weight relative to length at birth e.g., ponderal index (kg/m^3) have a higher degree of overweight or obesity in childhood and in adulthood. Heavy infants and those who grow rapidly are at increased risk of being obese later in life. From review study of Baird (2005: 929-934) suggests that both size and growth during infancy are related to risk of obesity in children and adults. Most studies of infant size found that infants who were defined as obese or who were at the highest end of the distribution for weight or body mass index were more likely to develop obesity in childhood, adolescence, or early adulthood than other infants. The importance of later weight, and of weight gain from early to later ages, suggests that obesity is the relevant factor in terms of growth. Therefore, greater body length at birth leads to greater sensitivity to body weight of blood pressure in adolescence Infants of low birth weight are more likely to suffer from such disease as hypertension, diabetes or coronary heart disease when they are adults (Cole, 2004: 201-204).

The coronary heart disease is a good example of a disease that develops throughout the life course. Although coronary heart disease manifests itself in adulthood, atherosclerosis, an important underlying process leading to the disease, begins at a much earlier age (Galobardes, 2004: 7–21). Girls who developed coronary heart disease in later life had slow intrauterine growth that led to shortness at birth. This was followed by compensatory growth in length during infancy and rapid increase in body mass index during childhood (Forse'n, 2004: 20-24). There are another two paths of growth associated with coronary heart disease. Thinness at birth was followed by rapid weight gain in childhood and failure of infant growth was followed by persisting thinness during childhood, both were associated with short stature in childhood. In addition, gain in weight and body mass index during infancy are associated with reduced risk of coronary heart disease. This reduction occurs irrespective of body size at birth (Eriksson, 2001: 949-953). The associations between birth weight, infant weight gain, and a range of mortality outcomes in the Hertfordshire Cohort were demonstrated in 2005. The results showed that respiratory disease mortality is related to early size and infant weight gain, with the strongest associations between lower birth weight and increased risk of mortality from pneumonia in women and between reduced infant weight gain and increased risk of chronic obstructive pulmonary disease mortality in men (Syddall, 2005: 1074–1080).

The findings in longitudinal study of Parsons (2001: 1331-1335) are potentially important because the combination of low birth weight and rapid linear growth has been identified as a risk for other cardiovascular risk factors, such as increased blood pressure. For men, the relation between childhood growth and adult obesity varied by mother's weight or body mass index as well as by birth weight, with a stronger positive association in those men whose mother had a lower weight or body mass index. The established links between birth weight and weight at one year and mortality from heart disease, strokes, and stomach cancer, further clarification of the relative roles of biological, demographic, and environmental factors in birth weight and infant weight gain are important for an understanding of adult disease mortality (Razzell, 2004: 1228–1233).

Chiang Rai Province is the northernmost border of Thailand, 90% of the whole area comprises high mountains. Mae Chan is a district in Chiang Rai Province.

There are 11 sub-districts and 136 villages in area 790 km^2. The population in this district approximately a hundred twenty thousand. There is the homeland of many groups of people, including lowland and upland people. Lowland people or call “Khon Muang” is local people who live in lowland area. Most of them came from Chiang Mai, Lamphun, Lampang, and Phrae for long time ago. Their life-style and culture are similar as Lanna origin, but a bit difference in speaking and writing language. Agriculture is the most important career of the people in Chiang Rai. The crops here are rice, corn, tea and tobacco. In addition, there are pig and poultry farms. Besides that they are excellent craftsmen, very keen on wood carving, weaving, lacquer ware making, instrument making, silk and cotton industries. They are almost Buddhist, however, some are Christian. Some other rituals are their local practices, such as a ceremony to bless people at a crucial time of their life, to bless someone with longevity, and to make merit to area temples (Breslau, 2001: 711-7; Brand, 2003: 729-37; www.ichiangrai.com, 2005).

Upland people or call “hilltribe” is minority ethnic group in Northern Thailand that is various groups such as Akha, Lahu, Lisu, Karen, Hmong, etc. These people have their own customs and traditions. There are 7 hilltribes in Mae Chan District; Akha or Ei-Ko, Yao or Iu Mien, Lahu or Musur, Karen or Kaliang or Yang, Lisu, Lua or Lawa, and Taiyai or Shan. Hilltribe’s originating in Burma, Laos, China, Tibet, and Cambodia, most have migrated to Thailand in the last 150-200 years. Most people were fleeing form fighting in these countries and the migration continues today. Karen people were the first Hill Tribe who has migrated to Thailand, followed by Lisu, Lahu and most recently Akha. When they came to Thailand, Hill Tribe people chose to live in the highland areas in harmony with nature, similar to their origins. They have the rights to use the land, but no ownership. Food and non-timber products are collected from the forest and river. If the villagers are sick, they can go to the forest and collect herbal medicine to treat most illnesses. Most traditional houses are built from bamboo and wood collected from the forest. Each tribe is different in culture, custom, costume, beliefs and language. The majority of hilltribe people are farmers, their lives largely dictated by the rhythm of the seasons. Their basic crops are mountain rice in the wet season and corn in the dry season. A variety of other vegetables and fruit are also grown. Animals are hunted when time is available especially Lahu (Busato, 1997: 9-22). In addition they also make some craftsmanship includes weaving, pottery, woodcarving, and making bronze-ware such as Taiyai. On special occasions, Yao women and children wear silver neck-rings, with silver chains extending down the back decorated with silver ornaments. The hilltribes are predominantly animists, but some are Christian and Buddhist minorities such as Karen, Yao and Akha. Most of their houses are on stilts, made of bamboo or wooden planks or teak. High, leafy plants were cut and switched for roofing (Chidambaranathan, 2004; www.ichiangrai.com, 2005). A main problem related with the lives of hilltribe is that many do not possess Thai citizenship. This lack of status prohibits them from most standard right of Thai people e.g. owning land, voting, and especially healthcare. Giving birth is the most dangerous time for all hill tribe people. Amongst women, complications in childbirth are the most common cause of death, and infant mortality is very high. The average number of births per couple is six, partly to offset infant mortality. Children are insurance for their parents against sickness and death, so it is vital to have enough to ensure that some survive to adulthood (Busato, 1997: 9-22).

Generalized Estimating Equations (GEE) were developed to extend the Generalized Linear Models (GLM) to accommodate correlated data, and are widely used by researchers in a number of fields. GEE is an analytic tool with promise for organizational research because the method accounted for correlation of responses within subject for outcome variables and was flexible enough for use in analyzing outcome variables that were not normally distributed, and use in analyzing longitudinal or repeated measures research designs. The GEE method has been very popular to estimate the parameters included in the mean function of repeated measurements. This method does not require correct specification of the correlation structure for consistent estimation of the regression parameters. GEE allows for missing observations, and provides consistent estimators for the parameters and their variance-covariance matrix under missing completely at random (Jung, 2005: 2583–96). GEE enable to estimate regression parameter consistently in longitudinal data analysis even when the correlation structure is misspecified. The method has received wide use in medical and life sciences such as epidemiology, gerontology, and biology (Qu, 2000: 823-836; Ballinger, 2004: 127-150).

In year 2001, there are 513 children, who residence in Mae Chan District, were born in Mae Chan Hospital, and 39% is hilltribe children. Male children are 57% and 43% of lowland and hilltribe children, respectively. With significance level 5%, birth weight among hilltribe and lowland children are significantly difference (p = 0.04; hilltribe children: mean = 3,137 grams, standard deviation (sd = 30.5; lowland children: mean = 3,054 grams, sd = 25.8). However, low birth weight (defined as birth weight <2500 grams) children in both group is not difference (p = 0.92). Birth length among two groups also significantly difference (p = 0.02; hilltribe children: mean = 51.3 cm, sd = 0.18; lowland children: mean = 50.7 cm, sd = 0.19). These statistics indicate that there are some difference characteristics between hilltribe and lowland children. Children growth is influenced by many factors such as gestational age, term of pregnancy, birth weight, breast feeding or formula feeding, parental stature, environment, nutrition, chronic illness or special health care needs. Whatever, the several of culture, beliefs, and life-style may be affect to growth in hilltribe children and also different from lowland children. However, to date, there have been few studies on the growth pattern of hilltribe children. The objective of this study was to examine the growth pattern and the factors affect to growth of hilltribe children and also in lowland children.

1.2. Research Questions

This study proposed two research questions to be investigated.

1. What is the growth pattern of hilltribe and lowland children?
2. What are the factors affect on growth comparing between hilltribe and lowland children?

1.3. Objectives

The study has following two objectives.

1. To construct Generalized Estimating Equation (GEE) models for growth pattern of hilltribe and lowland children who were born in Mae Chan Hospital.

2. To describe growth pattern and identify the factors affecting on growth of hilltribe and lowland children who were born in Mae Chan Hospital.

1.4. Scope of the Study

Longitudinal birth cohort studies provide a rich source of information about antecedents of disease that originates in pregnancy or childhood. In this study, the birth cohort children listed in Mae Chan Hospital from delivery registration between years 2001-2004 will use to demonstrate the growth pattern of hilltribe and lowland children. The data collection included neonatal and maternal factors. The growth indices are weight for age, length for age, head circumference for age, and ponderal index following from weight, length, and head circumference at birth, 2-, 4-, 6-, 9-, and 18-month.

1.5. Definition of Terms

Ethnicity is defined as lowland and hilltribe by using maternal ethnicity from delivery registration.

Gender is sexual identify for individual child, defined as male or female.

Weight was measured in kilograms generally, included birth weigh. Birth weight was dichotomized into low birth weight with birth weight less than 2.5 kg and normally birth weight equal or more than 2.5 kg.

Length was body length, measured in centimeters.

Head circumference was measured over the most prominent part on the back of the head (occiput) and just above the eyebrows (supraorbital ridges), in centimeters.

Ponderal index was used as a measure of relative weight and length in childhood, calculated as (birth weight (kg))/(birth length (m))^3. This index was a measure of soft tissue growth in children.

Gestational length or gestational age is defined as the number of completed weeks from the first day of the last menstrual period to the day of birth. Gestational length was dichotomized into prematurity or preterm births with gestational length less than 37 weeks and maturity or term births with gestational length equal or more than 37 weeks.

Pregnancy order referred to the number of pregnancy such as first time pregnancy or do not first time pregnancy. Multiple pregnancies referred to pregnant more than one time.

Birth order referred to the actual place in the family, such as only, oldest, middle and youngest child.

Birth spacing/interval is the interval between one pregnancy (current pregnancy) and the conception of the previous.

Numbers of children at deliver referred to number of infant when delivery, such as singleton was an offspring who born alone, twins were any of two children delivered at the same birth, and triplets were any of three children delivered at the same birth. Multiple births referred to twins or triplets.

Delivery method will separate in three methods; deliver normally, cesarean section and other delivery method such as vacuum extraction, forceps extraction, and breech birth assisting.

Maternal age is age in year of mother at pregnancy.

Maternal HIV status is results of human immunodeficiency virus (HIV) infection in mother, defined as positive or HIV infected and negative or HIV uninfected.

Maternal hematocrit is measured before deliver. Hematocrit is the percent of whole blood that is composed of red blood cells. It is measure of both the number of red blood cells and the size of red blood cells. The hematocrit indicates the proportion of cells and fluids in the blood. Normal values of hematocrit among male and female were 40.7-50.3 percent and 36.1-44.3 percent, respectively. The abnormal results will be the risk of excessive bleeding, fainting or feeling light-headed, hematoma (blood accumulating under the skin), infection (a slight risk any time the skin is broken), or multiple punctures to locate veins, etc.

Antenatal care (ANC) visits are the routine care for healthy pregnant women. Visits are usually monthly to 28 weeks, fortnightly to 36 weeks, then weekly to delivery. Each visit should involved checks on maternal and fetal well-being. These care should be include; weight gain (12 to 15 kilograms in total, with 3 kilograms in first 20 weeks), blood pressure (a diastolic pressure more than 90, or increase of more than 20 from first visit is significant), urinalysis, fetal movements, uterine size in accordance with dates and ultrasound, fetal lie, presentation, and engagement, especially after 36 weeks.

Weight for age, length for age, and head circumference for age were calculated in term of z-score. Z-score was more commonly used by the international nutrition community because of they offer many advantage. First, using z-score would identify a fixed point in the distributions of different indices and across different ages. The score is a measure of an individual's value with respect to the distribution of the reference population. Further, the useful summary statistics can be calculated. The approach allows the mean and standard deviation to be calculated the z-score for a group of children. The z-score application is considered the simplest way of describing the reference population and making comparisons (www.fantaproject.org, May 5, 2007; Gibson, 2005). The z-score is defined as the difference between the value for an individual and the median value of the reference population for the same gender and age, divided by the standard deviation of the reference population. The reference population was referred to the local reference of Thailand from Nutrition Division, Department of Health, Ministry of Public Health, Thailand (1999). Therefore, weight for age z-score, length for age z-score, and head circumference for age z-score were calculated as following.

Weight for Age z-score *was calculated as;*

$$= \frac{\text{Weight of Child} - \text{Median Reference Value of Weight for the same gender and age}}{\text{Standard Deviation of Weight in Reference for the same gender and age}}$$

Length for Age z-score *was calculated as;*

$$= \frac{\text{Length of Child} - \text{Median Reference Value of Length for the same gender and age}}{\text{Standard Deviation of Length in Reference for the same gender and age}}$$

Head Circumference for Age z-score *was calculated as;*

$$= \frac{\text{Head Circumference of Child} - \text{Median Reference Value of Head Circumference for the same gender and age}}{\text{Standard Deviation of Head Circumference in Reference for the same gender and age}}$$

Overall growth index was the new child growth indices that constructed from weight, length, and head circumference by using factor analysis.

Growth pattern refers to the change over time of five growth indices; weight for age, length for age, head circumference for age, ponderal index, and overall growth index during aged less than and equal 18 months.

CHAPTER II
LITERATURE REVIEW

This study has reviewed relevant researches and theories in the following topics:

2.1. Seven Hilltribes in Mae Chan District

2.2. Children Growth Factors

2.3. Generalized Estimating Equation (GEE)

2.1. Seven Hilltribes in Mae Chan District

Upland people or call “hilltribe” is minority ethnic group in Northern Thailand that is various groups such as Akha, Lahu, Lisu, Karen, Hmong, etc. These people have their own customs and traditions. There are 7 hilltribes in Mae Chan District; Akha, Yao or Iu Mien, Musur or Lahu, Karen or Kaliang or Yang, Lisu, Lua, and Taiyai or Shan (http://dnfe5.nfe.go.th, November 24, 2006).

Lisu or Lisor originated in Eastern Tibet, and the first settlers arrived in Thailand at the beginning of this century. Some came from Salawin basin in China. They are mainly found in northwest Thailand, and often live in close proximity to other groups. The Lisu live at moderate to high altitudes, though many are now moving down into lowland areas. Their houses are built on the ground, with dirt floors and bamboo walls around a central ridge. They build houses on high poles and on the ground. They grow corn and rice, while men are also expert hunters. They are animist, and also Buddhism (www.ichiangrai.com, 2005; www.lanna.com, November 24, 2006).

Karen or Kaliang or Yang people are a gentle, reserved, warm and elegant people. Their culture is rich in legend and tradition, their customs complex, deep and strictly adhered to. They are found along most of the length of the Thai-Burmese border over 200 years. They have a strong belief in sexual morality, and severe punishments for those who break their laws. They are animists and also believe in a Messiah figure. They like to live in the valleys and along the riverbanks. Houses are on stilts, made of bamboo or teak. Central steps lead to a porch, with a storeroom or kitchen to one side, a living area, and bedroom on the other. Beneath the house is a working area, often with foot-operated rice ponder. They are animist and Buddhist together (www.ichiangrai.com, 2005; www.lanna.com, November 24, 2006).

The Akha are call in Thai as Ei-Ko, originated from Tibet, Burma, Laos and Yunnan in China, have only recently entered Thailand, about 60-80 years ago. They are found only in the north of Thailand; Chiang Rai, Chiang Mai, Tak, Kamphaengphet, Phare, Lampang, and Pethchaboon. The Akha people are rightly famous for their very exotic and beautiful costumes, who are usually of small stature, dark skin and fine, delicate features. Their houses are on low stilts, with a large porch leading into a square living area with a stove, usually at the back. The roof is steeply pitched. They are deeply superstitious (in the Western sense), but some presently are Christian (www.ichiangrai.com, 2005; The Mirror Foundation, November 24, 2006; www.se-ed.net, November 24, 2006; www.lanna.com, November 24, 2006).

Lahu or called Musur in Thais are expert hunters and planters, also worship spirits. They originated in southwest China, and have migrated into Thailand from northern Burma. Most of their settlements are concentrated close to the Burmese border, in Chiang Rai, northern Chiang Mai, and Mae Hong Son. Lahu villages are generally at high altitudes. Houses are built on high stilts with walls of bamboo or wooden planks, thatched with grass. A ladder leads to an open central living area, with a storeroom to one side and living quarters to the other. There is one large bedroom, partitioned off as necessary according to family size. The main room has a central fireplace. A high proportion – about one third – of Lahu has been converted to Christianity, and many have abandoned their traditional way of life as a result. Animist Lahu believe in one spirit with overall control all the others (www.lanna.com, November 24, 2006).

Lua or Lawa is an Austronisian group. The originating is unclear but someone believed that they come from Burma and China for long time ago. They live at highland areas and so far from town, which one village included 20-100 households.

Their houses are on stilts like Karen's style, but the roof is steeply pitched and thatched with cogon grass or banana leaves. Their economy is based on subsistence agriculture, with rice grown on terraces according to a sophisticated rotation system. In addition, they grow corn, bean, cucumber, chilli, cotton, and other vegetables. Animal feeding are for eating and offer sacrifices to a spirit such as cow, buffalo, pig, chicken, dog, etc. They are animist, but many of them have adopted Buddhism (www.se-ed.net, November 24, 2006).

Yao or sometimes called "Iu Mien" are a very peaceable and friendly people, who pride themselves on cleanliness and honor. They have grace and elegance, and often a naturally aristocratic demeanor. They are extremely sociable and open, and are delighted to play hosts to visitors. They came from Laos and southern China. Their villages are widely scattered throughout the Northeast, with concentrations around Nan, Phayao and Chiang Rai. On special occasions, women and children wear silver neck-rings, with silver chains extending down the back decorated with silver ornaments. They grow corn and other crops. Their houses are often at high altitudes, built usually of wooden planks on a dirt road. There is a guest platform of bamboo in the communal living area, and two or more bedrooms. They are animist and Buddhist together, however, some are Christian only (www.ichiangrai.com, 2005; www.lanna.com, November 24, 2006).

Taiyai or called "Ngiao" by the Thais who call themselves "Tai" are moved from Shan State in Burma, Yunnan Province in south-west China, and some local north Thai people. Ethnically related to the Thai, name means "elder brother of the Thai". They came to settle in Mae Chan, Mae Sai, and Mae Fa Luang District. They grow rice, farm, raise cattle, and trade. Their craftsmanship includes weaving, pottery, wood carving, and making bronze-ware (www.ichiangrai.com, 2005; Adams, 2003; www.statelessperson.com, November 24, 2006; www.ywam.no, November 24, 2006).

2.2. Children Growth Factors

Measuring a child is important in the first few months of life, which are a powerful predictor of infant growth and survival. The most widely used anthropometric measures of the body size were weight, length, and head circumference. These measures can be made quickly and easily. Weight is body weight of children. Length is the recumbent length that is measured in infants and children aged less than 2 years, while height is measured in older children and adults in the standing position. Head circumference is the measured distance, in centimeters, around the widest part of the skull is larger than expected for the age and background of the child. The children growth indices such as weight for age, length for age, and head circumference for age are derived from these measures. Weight forage reflects body mass relative to chronological age. Low weight for age is described as lightness and reflects a pathological process referred as underweight. Length for age is a measure of achieved linear growth that is used as an index past nutritional or health status. Low height for age is defined as shortness and reflects either a normal variation or a pathological process involving growth failure. Head circumference for age is used as an index of chronic protein-energy deficiency for children aged less than 2 years. Chronic malnutrition during the first few months of life, or intrauterine growth retardation, may hinder brain development and result in an abnormally low head circumference (Gibson, 2005). Weight for age, length for age, and head circumference for age were the anthropometric indices compared to the reference population. The comparison of indices with the reference population can be use percentiles, percentage of median, or z-score. Among three methods, the z-score is a more sensitive descriptor than other. The z-score represents the number of standard deviations above/below the median weight for a reference population at that age. Further, z-score can be applied to the individual or population, pinpoint any given weight and height, nothing improvement or deterioration over time in relation to the reference values, and classify children of all ages and sizes equally. Ponderal index was infant body proportionality, calculated as (birth weight (kg))/(birth length (m))^3, used as a measure of relative birth weight and length and soft tissue growth in childhood. Ponderal index was a measure of fatness at birth that used for prediction of adolescent body mass index. A lower ponderal index indicates a longer, thinner infant, while a higher ponderal index indicates a shorter and/or fatter infant. These indices will be the indicators for some problem in children, adolescent, or adult such as malnutrition, under or over nutrition, obesity, or other chronic diseases. Insufficient gain in weight and height may indicate chronic illness, negligence or other problems (Chidambaranathan, 2004). The difference in growth of infant in the first few months affects a person in many ways as social effect-literally, biological effect and psychological effect. Infants are growing rapidly and still developing immunity to diseases and are more vulnerable to many illnesses and environmental hazards than older children and adults. Therefore providing a child with a good start in life can have a profound effect on their passage through the life cycle. Growth faltering in weight for length is restricted to the first 15 months of life, followed by rapid improvement. As early infancy is the period of highest mortality and also may be the cause of many chronic diseases later. Mortality and morbidity in early infancy was associated with newborn factor such as birth weight, gestational age at delivery, pregnancy complication, etc. For the reviews related with the factors that affect to growth indices will be following.

2.2.1. Ethnicity

Race and ethnicity are increasingly being used as variables in health research. Race is a biological concept, which categorizes humanity by means of sets of phenotypical features, that appear to distinguish between varieties of people and are passed on between generations. Whereas, ethnicity is refers more to shared cultural characteristics and national identity. In Thailand, the main ethnicity is Thai but there are many minority ethnic groups. Upland people or call “hilltribe” is minority ethnic group in Northern Thailand that is various groups such as Akha, Lahu, Lisu, Karen, Hmong, etc. These people have their own customs and traditions. A main problem related with the lives of hilltribe is that many do not have Thai citizenship. This lack of status prohibits them from most human rights e.g. owning land, voting, minimum ages and especially healthcare. Birth is the most dangerous time for all hill tribe people. Amongst women, complications in childbirth are the most common cause of death, and infant mortality is very high. Children are insurance for their parents against sickness and death, so it is vital to have enough to ensure that some survive to adulthood (Busato, 1997: 9-22).

However, there is no evidence for growth differences between hilltribe and lowland children. Research related with these differences is rarely, however, the differences for growth in childhood between several ethnic can study from various research as following. There are some ethnicity differences in childhood growth, are relatively minor compared to worldwide variations in growth due to health and environment influences i.e., poor nutrition, infectious disease, socio-economic status. The differences in weight and growth of infants and children would remain if they all lived in a similar environment and received the same optimal nutrition and care. From review study, there are large differences in rates of low birth weight, defined as birth weight less than 2500 grams, and rates of hypertension, blood pressure higher than 140 mm Hg systolic and/or 90 mm Hg diastolic, between black and white Americans. Currently 13.3% of black women, versus 6.9% of white women, give birth to a low birth weight baby (Dressler, 2005: 231-52). Alexander (2003: 61-66) found that black women have higher proportions for preterm and low birth weight deliveries, compared with either whites or Hispanics. At the same time, blacks experience lower risks of neonatal mortality for preterm and low birth weight infants, while having higher risks of mortality among term, postterm, normal birth weight, and macrosomic deliveries. In addition, for infant mortality and low birth weight, African Americans have rates at least two times those for whites, and the gap has been increasing over time (Buescher, 2006: 16-20). In a retrospective cohort study to compare the risk of stillbirth between pregnancies of black and white mothers using the generalized estimating equations, indicated that black weighted significant less than white fetuses among singletons, twins, and triplets. However, risk of stillbirth in black fetuses was more than white fetuses among singletons and twins (Salihu, 2004).

2.2.2. Gender

Body size of female children is smaller than male normally because of gender differences in growth spurts and structure. According to a longitudinal dataset of weights collected routinely between delivery and 24 months from a birth cohort in Newcastle upon Tyne between 1987 and 1988 (Wright, 1996). This study found that the mean standard deviation score for weight of boys was 0.42 higher than that for girls after the age of three months, and twice as many girls as boys fell below the 3rd weight centile during the first year. These differences could result in substantial sex bias in the identification of poor growth in early childhood. According to a literature review (Lawlor, 2002), they believed that low birth weight is associated with high blood pressure and other cardiovascular disease outcomes in later life. Then the aim of this study was to determine whether a sex difference exists in the association between birth weight and systolic blood pressure. Of the 38 studies presenting combined results, 15 studies (39 percent) stated that there was sex difference in the association between birth weight and blood pressure. Blair (2005) demonstrated method of assessing the appropriateness of fetal growth by deriving equations for optimal birth weight, birth length and head circumference. Gestational duration, fetal gender and maternal height, age and parity are considered as potential independent variables representing the non-pathological determinants of fetal growth. Box-Cox transformation was used to identify the optimal transformation to reduce non-normality and heteroscedasticity of errors. Fractional polynomial regression was then used to identify the best-fit transformation. The result showed that all potential predictor variables significantly predicted head circumference, but was not a significant predictor of birth weight and length. Nevertheless, Christensen's study (Christensen, 2006) found that there were not consistent differences in postnatal weight pattern between male and female neonates.

2.2.3. Birth Weight and Low Birth Weight

Birth weight is the first weight of the foetus or newborn obtained after deliver, which is a powerful predictor of infant growth and survival. Generally, during the first three months, the average baby gains close to one kg a month. More than half of healthy infants will have doubled their birth weight within 3 to 4 months. By 6 months the average gain per month is down to 0.5 kg. Birth weight is usually tripled by the end of the first year and quadrupled by the end of second year (Lowrey, 1978).

Birth weight served as a good marker for growth potential, accounting for 5–6% of the total variance of future weight, height and body mass index (Diamond, 2001). Similarly, study of Gigante (2006) showed that height increased with birth weight, and adolescents born weighing more than and equal 4000 g were 9 cm taller than those who had a low birth weight. Birth weight for gestational age seemed to have a positive effect on adolescent height as well as on weight. Subjects who were of average length and heavy weight at birth had the highest risk for overweight in adolescence (Pietiläinen, 2001). The smaller baby, the more important it is to monitor his or her growth in the weeks after delivery. A baby's low weight at delivery is either the result of preterm delivery, which defined as born before 37 weeks of gestation, or of restricted foetal (intrauterine) growth. Low birth weight is closely associated with foetal and neonatal mortality and morbidity, inhibited growth and cognitive development, and chronic diseases later in life. Infants born with a low birth weight begin life immediately disadvantaged and face extremely poor survival rates (Pojda, 2000). Results of the conditional regression models showed that birth weight was significantly associated with cognitive function (reading comprehension, word pronunciation, vocabulary, and non-verbal reasoning) at age 8 years, with cognitive scores increasing across the four lowest birth weight categories, then declining at the highest birth weight category. They spilt birth weight into five categories: less than 2.51, 2.51 to 3.00, 3.01 to 3.50, 3.51 to 4.00, and 4.01 to 5.00 kg. Adjustment for sex, father's social class, mother's education, mother's age, and birth order strengthened this overall association, and the trend became more linear through raising the coefficient for the highest birth weight category (Richards, 2001: 199-203). An adverse intrauterine environment, defined as low birth weight or low ponderal index at birth (kg/m^3), was used to predict a value of low insulin sensitivity index in a random sample of young, healthy Danes in 1997 (Clausen, 1997: 23-31).

There are many evidences link low birth weight due to intrauterine growth restriction and increased risk of vascular disease in later adult life. Some literature studies summarized the association between low birth weight and risk of cardiovascular disease in later life (Sattar, 2002: 157-160). Eriksson (2001: 949-953) found two paths of growth associated with coronary heart disease. Thinness at birth was followed by rapid weight gain in childhood and failure of infant growth was followed by persisting thinness during childhood, both were associated with short stature in childhood. In addition, gain in weight and body mass index during infancy are associated with reduced risk of coronary heart disease. This reduction occurs irrespective of body size at birth. Furthermore, systematic review was used to assess the association between infant growth and subsequent obesity and to establish whether groups of infants with particular patterns of growth are at greater risk. Both size and growth were considered because each is important in understanding the growth status of an infant, for example, an infant may be small but be growing rapidly. Most studies of infant size found that infants who were defined as obese or who were at the highest end of the distribution for weight or body mass index were more likely to develop obesity in childhood, adolescence, or early adulthood than other infants (Baird, 2005: 929-934). In the Hertfordshire Cohort Study, lower birth weight in men was associated with increased risk of mortality from circulatory disease and from accidental falls but with decreased risk of mortality from cancer. For women, lower birth weight was associated with a significantly increased risk of mortality from circulatory and musculoskeletal disease, pneumonia, injury, and diabetes (Syddall, 2005).

2.2.4. Birth Length

Body size also tracked from birth to adolescence when length and weight at birth were combined. Subjects who were short and light at birth were still short and light at age 16 years, and those who were long and heavy at birth were tall and heavy at age 16 years. Birth length was a clear indicator of adolescent height, however, height in adolescence was predicted by length and weight at birth and by parents' height (Pietiläinen, 2001). The annual increments in height continually diminish from birth to maturity. By the end of the first year the infant has increased his/her birth length by about fifty percent, has doubled it by age four years (Lowrey, 1978). Further, birth length was strongly associated with development at first year of age, but only infants born both short and thin were at increased risk of mortality and hospitalizations. (Morris, 1998: 242-247).

2.2.5. Birth Head Circumference

Head circumference is routinely measured at birth along with birth weight and length. Although head circumference is relatively strongly associated with both birth weight and birth length, it is thought particularly to reflect brain size. Head circumference is related to intracranial volume and permits an estimation of the rate of brain growth. The circumference of male head is slightly being greater than female (Lowrey, 1978). Infants with a large head circumference have a rapid intrauterine growth, making them particularly susceptible to undernutrition in late gestation and thereby to disproportionate growth and impaired thymus development. Further, in premature infant and in older suffering from malnutrition, the head is large in relation to the weight (Illingworth, 1980). The small head circumference in adult was indicated to poor growth in very early life and childhood. The correlations in head circumference for first, second, third and fourth child decreased as distance between birth orders increased, but tended to increase slightly from first and second child to third and fourth child (Samuelsen, 2004). In addition, polymorphism of the insulin gene (INS) variable number of tandem repeats (VNTR; class I or class III alleles) locus has been associated with adult diseases and with birth size. The III/III genotype association with larger head circumference at birth also showed significant interaction with birth order (interaction $p<0.02$), such that the association was observed in the offspring of mothers' second and subsequent pregnancies. During childhood, the III/III genotype remained associated with larger head circumference and was also associated with greater body mass index, waist circumference, and higher fasting insulin levels in girls (Ong, 2004).

2.2.6. Ponderal Index at Birth

High birth weight has been associated with overweight and obesity in children , adolescents , and adults. Likewise, infants of high weight relative to length at birth e.g., ponderal index (kg/m3) have a higher degree of overweight or obesity in childhood. In Brazilian infants, the effect of birth anthropometry on suspected developmental delay at one year was quite different from the effect on mortality and hospitalizations. There was a clear reduction in the risk of developmental delay with both increasing length at birth and (to a lesser degree) increasing ponderal index, but no interaction between the two. In addition, infants with low length measures at birth showed no clear tendency to catch up in linear growth, whereas those with low ponderal indices were protected from the decrease in ponderal index over infancy experienced by infants with average or high ponderal indices at birth (Morris, 1998: 242-247). They concluded that infants who were born both short and with low ponderal index were at increased risk of mortality and severe morbidity in infancy. The combination of birth length and ponderal index at birth may well provide a functionally relevant means of classifying the newborn infant's anthropometric status, since the two measures are relatively independent of each other at the level of the individual, and appear to bear upon different aspects of the infant's subsequent health and development. In a randomized trial (Fewtrell, 2001) found that ponderal index at birth showed a significant negative association with gains in weight, length, and head circumference between birth and 18 months. Therefore, infants with a lower ponderal index at birth had significantly greater gains in weight, length, and head circumference by 18 months of age.

2.2.7. Gestational Age and Preterm Delivery

The children who were born before 37 weeks of gestation were referred as preterm children, and those weighing at birth 2.5 kg or less as low birth weight children. Low birth weight in relation to the duration of gestation may be due to malnutrition, abnormalities of the placenta, hereditary or other factors. Prematurity and intrauterine growth retardation (a condition where foetal growth has been constrained) are the two main causes of low birth weight (Pojda, 2000). Additionally, Girls who were small for gestational age at birth were about 5 cm shorter than all others (Gigante, 2006). In many cases, the causes of prematurity are unknown; they may include high maternal blood pressure, acute infections, hard physical work, multiple births, stress, anxiety, and other psychological factors. The analysis of the National Center for Health Statistics of the Centers for Disease Control and Prevention demonstrated nonparametric logistic regression based on generalized additive models of neonatal mortality. The associations between neonatal mortality and each of the three factors z-score birth weight, gestational age, and number of cigarettes smoked per day separately were examined. Both standardized z-score birth weight and preterm delivery are strongly associated with neonatal mortality, and the effect of maternal smoking appears largely mediated largely through reduced fetal growth and, to a smaller extent, through shortened gestation (Ananth, 2004: 22). Literature study of Satter (2002: 157-160) also explained the association between preterm delivery and coronary heart disease might therefore be related to up regulation of chronic inflammatory pathways.

2.2.8. Maternal Age at Pregnancy

In general, the older mother were had a chance of higher stillbirth rate, perinatal mortality, prematurtity rate, and more mongolism, more than the younger mother (Illingworth, 1980). The Child Health System has routinely recorded perinatal data on Northern Ireland births since 1965. Maternal age at delivery, birth weight and gestational age, were taken directly from birth notification forms completed in obstetric units. These data was use to study the relationship between Type 1 diabetes and various perinatal factors in UK. Increased Type 1 diabetes risk was associated with higher maternal age, paternal age, birth weight and birth weight for gestational and lower gestational age. Although adjustment for maternal age, the association between Type 1 diabetes and paternal age remained significant. Inversely, increased birth order was associated with a significant decrease in the risk of Type 1 diabetes, only for diabetes diagnosed under the age of 5 years, but this only became apparent when adjustment was made for maternal age (Cardwell, 2005: 200-206). Similarly, cox regression analysis of the Bart’s-Oxford family study of childhood diabetes showed that firstborn children are at greater risk than children of higher birth order, and high maternal age also increases the risk in offspring. Maternal age at delivery was strongly related to risk of type 1 diabetes in the offspring; risk increased by 25% (95% CI 17% to 34%) for each five year band of maternal age, so that maternal age at delivery of 45 years or more was associated with a relative risk of 3.11 (95% CI 2.07 to 4.66) compared with a maternal age of less than 20 years. Risk increased with increasing maternal age at delivery and was less strongly associated with increasing paternal age (Bingley, 2000: 420-424). Maternal age and parity both have independent effects on child health and tend to vary both together and with interval. These also were affected to morbidity and mortality in mother and children (Winikoff, 1983: 231-245). The age of mother has a bearing on fetal development. The older mother, the greater is the incident of anomalies of the central nervous system, mongolism, metal retardation, premature labor and dizygolic twins.

2.2.9. Maternal HIV Status

Maternal HIV status is one factor that effected to neonatal growth. The prospective cohort study in Congo, to investigate growth in length, weight, and weight-for-length of children born to seropositive mother and seronegative mother, children was separate three groups; HIV-positive children born to seropositive mother, HIV-negative children born to seropositive mother, and children born to seronegative mother as control group. The result showed that there was no significant difference in mean length at birth between the three groups of children, but by three months of age, HIV-infected children were significantly shorter than both uninfected and control children. In the other hand, the mean weights at birth of infected and uninfected children were similar to each other, but significantly less than that of controls. By three months of age, the mean weight of uninfected children had caught up to controls, while infected children fell significantly below that of the other two groups (Bailey, 1999: 532-540). Furthermore, the study of growth in children in mother with HIV infection indicated neither length nor weight was associated significantly with the main effects of HIV infection status at birth, but differences between infected and uninfected children increased with age. Uninfected children were significantly taller and heavier from very early ages, and by 10 years of age, they were estimated to be taller than infected children (The European Collaborative Study, 2003). In addition, the result of Uganda study by using GEE analysis found that weight-for-age among HIV-infected below –1.5 Z-scores have five times the risk of dying before the age of 25 months compared with non-infected children. Similarly, differences are noted in the length-for-age in infected children, non-infected children, and control. The summary is mean weight-for-age and length-for-age curves of HIV-infected children were significantly lower than non-infected children and control (Berhane, 1997: 7-12).

2.2.10. Pregnancy Order

Motherhood is a unique event in a woman's life. First time pregnancy is very exciting but also very frightening and nervous. However, preparing for next pregnancy can be as rewarding and special as the first time, the mother now have added responsibilities and considerations in order to prepare. Primiparous woman is a woman who is pregnant for the first time, while a woman who is pregnant more than one time defied as multiparous. Multiparous mother are usually know better than primiparous about how to take care herself when pregnancy and also know how to take care her offspring such as milk feeding, food and nutrition intake, health concern, or child development. It seems that when women have given birth several times before or multiparous women, they often have a long prelabor period where contractions may build up, but labor does not become established. It may be hard for them to be sure when they are going into labor, because labor appears to start, then contractions stop. The multiparous women were at higher risk of postpartum haemorrhage and some other complications, because the uterus might lose its elasticity and therefore might not contract down well after the birth. In a match cohort study (Bugg, 2002) that was aim to compare the incidence of antenatal and intrapartum complications and neonatal outcomes among women who had previously delivered five or more times, defined as grand-multiparous, with that of age matched control women who had previously delivered two or three times , defined as multiparous. The results were that the overall incidence of intrapartum complications for grand-multiparous women was not differed from the control multiparous women (OR=0.9, 95%CI 0.6–1.3). Grand-multiparity was associated with a significantly higher body mass index at booking ($p<0.01$) and the last antenatal clinic ($p<0.05$), an increased incidence of antenatal anaemia (OR=1.8, 95%CI 1.2–2.8) and a decreased incidence of elective caesarean section (OR=0.5, 95%CI 0.3–0.9). They concluded that grand-multiparity should not be considered dangerous, and risk assessment should be based on past and present history and not simply on the basis of parity.

2.2.11. Birth Order

In the population-based Avon Longitudinal Study of Pregnancy and Childhood birth cohort (Ong, 2004: 1128–1133), have confirmed the association between genotype and head circumference. This association was influenced by maternal birth order/parity, showed that the larger head circumference was stronger in second and subsequent pregnancies than in first pregnancies. The birth order was also an important marker of maternal-uterine environment, with first-born infants being more likely to be restrained in utero than subsequent offspring. Compensatory rapid postnatal weight gain was seen more often in offspring of first pregnancies (35%) than in offspring of second and subsequent pregnancies (17%). The parity effect on birth weight has been explained in part by the increased maternal pre-pregnancy weight of the multipara, with the relative plethora of blood vessels and supporting tissues in the obese woman. There was a linear relationship between birth order and birth weight within the same socio-economic status group, based on linearity test analysis of variance The mean birth weight of children born to multiparous women within the lower socio-economic status neighbourhood was significantly greater than for single births or for small families within the same community. Additionally, in later childhood higher birth order has an inverse correlation with height, namely later born children, if not necessarily lighter, are certainly shorter than the first born in the same family and than children from smaller families in general (Diamond, 2001). Further, Multivariate analysis showed that increasing birth order conferred some protection. The relative risk of diabetes, adjusted for parental age at delivery and sex of offspring, decreased with increasing birth order; the overall effect was a 15% risk reduction (10% to 21%) per child born. Therefore, risk was highest in firstborn children and decreased progressively with higher birth order when mater age at pregnancy was adjusted (Bingley, 2000: 420-424).

2.2.12. Birth Spacing

Birth spacing/interval is the interval between one pregnancy and the conception of the previous. The important of birth spacing for health has been a key of family planning, supplementary, birth spacing might improve health for mothers and their children. Close spacing of births may effect to children such as more infant mortality, lower intelligence quotient, contact with mother less, or phychological. Short birth intervals may lead to higher mortality concerns the transmission of disease. Larger numbers of young children within the household may facilitate not only the spread of infectious disease but the severity of infection as well. Parental attention and investment in resources may be diverted from the older child to the newborn. Even ignoring this briefest interval, the risk of neonatal mortality to infants born 13 to 8 months after their previous sibling is twice as high as to infants born after intervals of 55 months or longer (Koeing, 1990: 251-265). A short birth interval in and of itself is sufficient to increase the odds of low birth weight. For the reason that short intervals may not give women adequate time to build up nutritional reserves and a result is infant of low birth weight (Gribble, 1993: 133-146). Adopting birth spacing and reducing the incidence of low birth weight would have implications for mortality, morbidity, and the demand for health services. In addition, older women tend to have longer intervals between births than younger women, and they have different patterns of reproductive loss. Higher parity is associated with shorter average birth intervals, and effects attributed to short interval may be reflections of the biological risks of high parity or the social detriments of large families. For post neonatal mortality, births less than two years after a prior birth appear to have an elevated risk, but beyond two years, there is no decrease in risk with increasing interval (Winikoff, 1983: 231-245).

2.2.13. Delivery Method

Women experienced severe obstetric complications, such as hemorrhage requiring a blood transfusion or hospitalization, dystocia/ mainly obstructed or prolonged labor, hypertensive disorders such as eclampsia, preeclamsia and hypertension, and sepsis, were increased severe maternal morbidity later. The most frequently reported delivery-related complication was long period of deliver, depends on maternal characteristics like age and order of pregnancy. Institutional deliveries would result in use of medical intervention in order to facilitate better outcomes. Delivery-related complications were significantly higher among those who had accessed antenatal care and those who had institutional deliveries. Caesarean section has been listed as one of several delivery-related complications experienced by women (Mishra, 2002: 90-98). In the 1987, Finnish Medical Birth Register study evaluated the incidence of asthma in children born by vaginal delivery or caesarean section a cohort. Data were analyzed by χ^2 -and t-tests. Odds ratios (OR) with 95% confidence intervals (CI) were calculated for differences between the modes of delivery groups, using the vaginal delivery group as reference group. The results showed that the older mother, the smaller parity, the lower birth weight of the child, and gender of live births was male determined the likelihood of caesarean section delivery as being higher (Kero, 2002).

2.2.14. Number of Children at Delivery

Multiple births are associated with the higher incidence of mental retardation and of cerebral palsy than single pregnancy. Twins usually were lighter and shorter than singleton. All mothers expecting twins are at increased risk for the following: preterm delivery due to preterm labor, preeclampsia, anaemia, poor growth of the baby, increased blood loss with delivery, and caesarean section is often performed because one of the twins is not coming out head first. Twins are more often born to an older mother, and in multiple pregnancies there is a higher incidence of toxemia and hydramnios, both conditions that tend to be associated with fetal abnormalities. There is a high perinatal mortality in a co-twin of a twin who has cerebral palsy, suggesting that there had been antenatal factors acting on both twins. The smaller of twins is liable to suffer from hypoglycemia in the newborn period, and so to suffer brain damage if it is severe and inadequate treated (Illingworth, 1980). There is considerable evidence that twins are disadvantaged in terms of long-term growth and neurodevelopment status. According to a prospective follow up was undertaken to study the growth and development of twins. Parameters of growth and development of twins were compared with those of normal singletons at one and four years. At the age of one year, twins lagged behind in three growth parameters of length, weight and head circumference. At four years, they caught up with normal birth weight controls for head circumference, but remained shorter and lighter than controls (Chaudhari, 1997).

2.2.15. Maternal Hematocrit

Hematocrit is the percent of whole blood that is composed of red blood cells. It is measure of both the number of red blood cells and the size of red blood cells. The hematocrit indicates the proportion of cells and fluids in the blood. Normal values of hematocrit between male and female were 40.7 to 50.3 percent and 36.1 to 44.3 percent, respectively. Low hematocrit may indicate to anemia, blood loss (hemorrhage), bone marrow failure (e.g. due to rediation, toxin, fibrosis, or tumor), destruction of red blood cells, leukemia, malnutrition or specific nutritional deficiency, multiple myeloma, or rheumatoid arthritis. While, high hematocrit may indicate to dehydration (burn or diarrhea), erythrocytosis or excessive red blood cell production, or polycythemia vera. Supplementary, the risks of abnormal hematocrit were excessive bleeding, fainting or feeling light-headed, hematoma or blood accumulating under the skin, infection or a slightly risk any time the skin is broken, or multiple punctures to locate veins (Nanda, 2005). Associations between low maternal hematocrit at delivery and poor pregnancy outcome have been reported in some studies. Lower hematocrit typifies earlier stages of pregnancy when preterm delivery commonly occurs, and higher hematocrit values are associated with pregnancies delivered at later gestational periods. However, high hemoglobin concentration, elevated hematocrit and increased levels of serum ferritin late in pregnancy have been associated with increased preterm delivery (School, 2000). Using hematocrit values recorded earlier in gestation found only a very weak association between anemia and the risk of preterm delivery and only for hematocrit measured before the 30th week of gestation.

2.2.16. Antenatal Care (ANC) Visits

Because of pregnant women should be offered evidence-based information and support to enable them to make informed decisions regarding their care. Information should include details of where they will be seen and who will undertake their care. Antenatal care (ANC) is routine care for healthy pregnant woman. In addition, ANC is a widely used strategy to improve the health of pregnant women and to encourage skilled care during childbirth. Normally, ANC visit is expected to help identify high-risk pregnancies and it is likely that this leads to an increase in institutional deliveries. Probably, ANC visits were be indirect effect for children growth, mother would got education during ANC visits. According to the study of delivery-related complications and caesarean section in selected states of India (Mishra, 2002) indicated that when a higher proportion of women receive ANC, it is expected that more women will be brought within the ambit of the health service. ANC is hypothesized as identifying women who are at risk of having pregnancy related complications and therefore results in higher incidence of elective cesarean sections. The results showed that delivery-related complications were significantly higher among those who had accessed ANC and institutional deliveries. Therefore, ANC is expected to help identify high-risk pregnancies and it is likely that leads to increase in institutional deliveries. Number of ANC visits, time used for each visit, counseling attitudes and skills of providers are important. ANC should address both the psychosocial and the medical needs of the woman, within the context of the health care delivery system and the culture. Periodic health check-ups during the antenatal period are necessary to establish confidence between the woman and her health care provider, to individualize health promotional messages, and to identify and manage any maternal complications or risk factors. ANC visits are also used to provide essential services that are recommended for all pregnant women, such as tetanus toxoid immunization and the prevention of anaemia through nutrition education and provision of iron/folic acid tablets. The antenatal period presents important opportunities for reaching pregnant women with a number of interventions that may be vital to their health and well being and that of their infants. Better understanding of fetal growth and development and its relationship to the mother's health has resulted in increased attention to the potential of ANC as an intervention to improve both maternal and newborn health. For instance, the antenatal period is used to inform women about the danger signs and symptoms or about the risks of labor and delivery. The antenatal period also provides an opportunity to supply information on birth spacing, which is recognized as an important factor in improving infant survival. Adverse outcomes such as low birth weight can be reduced through a combination of interventions to improve women's nutritional status and prevent infections, e.g. malaria and sexual transmission infection diseases during pregnancy (www.childinfo.org., May 2006). Absolutely, the healthy mother will give the healthy children.

2.3. Generalized Estimating Equations (GEE)

Generalized Estimating Equations (GEE) were developed to extend the Generalized Linear Models (GLM) to accommodate correlated data, and are widely used by researchers in a number of fields. GEE is an analytic tool with promise for organizational research because the method accounted for correlation of responses within subject for outcome variables and was flexible enough for use in analyzing outcome variables that were not normally distributed, and use in analyzing longitudinal or repeated measures research designs.

GEE are multivariate analogues of quasi-likelihood estimating equations. With scalar responses, there is usually a unique integral of the estimating function analogous to the likelihood function, hence the term quasi-likelihood. In the multivariate case, it is more common that the integral is not uniquely defined (Carey, 1993: 517-526).

GLM use maximum likelihood methods to estimate model parameters, requires likelihood function and the distribution of the response variable be specified. If the responses are independent, the likelihood can be expressed as the product of each observation’s contribution to the likelihood. Otherwise, if the responses are not independent, then the likelihood can become complicated, or intractable. For nonindependent outcomes whose joint distribution is multivariate normal, the likelihood is relatively straightforward, since the multivariate normal distribution is completely specified by the means, variances, and all of the pairwise covariance of the random outcomes. This is typically not the case for other multivariate distributions in which the outcomes are not independent. For these circumstances, quasi-likelihood theory offers an alternative approach to model development. Quasi-likelihood methods have many of the same desirable statistical properties that maximum likelihood methods have, although the full likelihood does not need to be specified. Rather, the relationship between the mean and variance of each response is specified. Just as the maximum likelihood theory lays the foundation for GLM, the quasi-likelihood theory lays the foundation for GEE models (Kleibaum, 2002: 327-375).

The GEE method has been very popular to estimate the parameters included in the mean function of repeated measurements. This method does not require correct specification of the correlation structure for consistent estimation of the regression parameters. GEE allows for missing observations, and provides consistent estimators for the parameters and their variance-covariance matrix under missing completely at random (Jung, 2005: 2583–2596). GEE enable to estimate regression parameter consistently in longitudinal data analysis even when the correlation structure is misspecified. The method has received wide use in medical and life sciences such as epidemiology, gerontology, and biology (Qu, 2000: 823-836; Ballinger, 2004: 127-150).

GEE was used to estimate correlations involving left-censored data, and compared with the Maximum Likelihood Estimation (MLE) approach via simulated normal and non-normal data. In summary, the proposed GEE method performs very consistently with ML for point estimation under bivariate normality. For heavy-tailed and moderately skewed non-normal data, both the GEE and ML methods remain relatively robust, with the GEE method marginally better than ML with respect to closeness of the estimated standard errors to the empirical standard deviations based on simulated data sets (Song, 2004: 245-257). A retrospective cohort study on twins delivered in 1995–1997 in the United States, associations between order of birth, first- or second-born twin, and mortality indices, stillbirth and neonatal and perinatal mortality, were analyzed by using multivariate logistic regression models based on generalized estimating equations with robust variance estimates (Sheay, 2004: 63-70).

To investigate dietary calcium intake is related to body mass index and the sum of four skinfolds among subjects in the Amsterdam Growth and Health Longitudinal Study. In 1977, boys and girls whose mean age was 13 years in a secondary school, Netherlands were assessed regarding a wide range of characteristics including dietary calcium intake and body composition. Three measurements on the same subjects followed annually from 1978 through 1980. Follow-up measurements were performed in 1985, 1991, 1996, and 2000 when the subjects were an average age of 21, 27, 32, and 36 years, respectively. Longitudinal linear regression analyses were performed with generalized estimating equations in continuous and categorical models, with adjustment for possible confounders. Results showed that calcium intake during adolescence are a weak predictor of calcium intake in adulthood. In this population, only a slight indication was found of a weak inverse relation of calcium intake with body composition. No differences were observed between the middle (800–1,200 mg/day) and high (>1,200 mg/day) groups of calcium intake, suggesting a threshold of approximately 800 mg/day above which calcium intake has no additional beneficial effect on body composition (Boon, 2005: 27-32).

GEE represent a class of models that are often utilized for data in which the responses are correlated. These models can be used to account for the correlation of continuous or categorical outcomes. Therefore, GEE is a generalization of quasi-likelihood estimation, so the joint distribution of the data need not be specified. For clustered data, the user specifies a working correlation structure for describing how the responses within clusters are related to each other. However, between clusters, there is an assumption of independence (Kleibaum, 2002: 327-375).

Twisk (2003: 60-68) considered the longitudinal relationship between a continuous outcome variable Y and one or more predictor variables X can be described by equation;

$$Y_{it} = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{itj} + \varepsilon_{it} \qquad (2.1)$$

where Y_{it} are observations for subject i at time t, β_0 is the intercept, X_{ijt} is the independent variable j for subject i at time t, β_{1j} is the regression coefficient for independent variable j, J is the number of independent variables, and ε_{it} is the error for subject i at time t. The subscripts t indicate that the outcome variable Y is repeatedly measured on the same subject, and that the predictor variable X can be repeatedly measured on the same subject. In model (2.1), the coefficients of interest are β_{1j}, because these regression coefficients show the magnitude of the relationship between the longitudinal development of the outcome variable (Y_{it}) and the development of the predictor variables (X_{ijt}). In addition of a time variable t as equation

$$Y_{it} = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{itj} + \beta_2 t + \varepsilon_{it} \qquad (2.2)$$

where Y_{it} are observations for subject i at time t, β_0 is the intercept, X_{ijt} is the independent variable j for subject i at time t, β_{1j} is the regression coefficient for independent variable j, J is the number of independent variables, t is time, β_2 is the regression coefficient for time, and ε_{it} is the error for subject i at time t.

From equation (2.2) can be expanded to a general form, in which a correlation for both time-dependent covariates (Z_{ikt}) and time-independent covariates (G_{im}) is modeled as equation;

$$Y_{it} = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{itj} + \beta_2 t + \sum_{k=1}^{K} \beta_{3k} Z_{ikt} + \sum_{m=1}^{M} \beta_{4m} G_{im} + \varepsilon_{it} \qquad (2.3)$$

where Y_{it} are observations for subject i at time t, β_0 is the intercept, X_{ijt} is the independent variable j for subject i at time t, β_{1j} is the regression coefficient for independent variable j, J is the number of independent variables, t is time, β_2 is the regression coefficient for time, Z_{ikt} is the time-dependent covariate k for subject i at time t, β_{3k} is the regression coefficient for time-dependent covariate k, K is the number of time-dependent covariates, G_{im} is the time-independent covariate m for subject i, β_{4m} is the regression coefficient for time-independent covariate m, M is the number of time-independent covariates, and ε_{it} is the error for subject i at time t. GEE is an iterative procedure, using quasi-likelihood to estimate the regression coefficients. Because the repeated observations within one subject are not independent of each other, a correlation must be made for these within-subject correlations. With GEE, assuming a priori a certain working correlation structure for the repeated measurements of the outcome variable Y carries out this correlation. The within-subject correlation structure is treated as a nuisance variable, i.e. a covariate. So, in principle, the way in which GEE analysis corrects for the dependency of observations within one subject is the way that has been shown in equation;

$$Y_{it} = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{itj} + \beta_2 t + \sum_{k=1}^{K} \beta_{3k} Z_{ikt} + \sum_{m=1}^{M} \beta_{4m} G_{im} + C_{it} + \varepsilon_{it} \qquad (2.4)$$

where Y_{it} are observations for subject i at time t, β_0 is the intercept, X_{ijt} is the independent variable j for subject i at time t, β_{1j} is the regression coefficient for independent variable j, J is the number of independent variables, t is time, β_2 is the regression coefficient for time, Z_{ikt} is the time-dependent covariate k for subject i at time t, β_{3k} is the regression coefficient for time-dependent covariate k, K is the number of time-dependent covariates, G_{im} is the time-independent covariate m for subject i, β_{4m} is the regression coefficient for time-independent covariate m, M is the number of time-independent covariates, C_{it} is the working correlation structure, and ε_{it} is the error for subject i at time t.

Because of difference in ethnicity, these can separate children in 2 groups; hilltribe and lowland, will be effect on the differences in the responses. Suppose that the ethnicity defines as the independent categorical variable X_{pit} for subject i at time

t, number of group (p) for X_{pit} is 2. Lowland children group is defined as p =1 and hilltribe is defined as p =2. The GEE equation to compare growth pattern between hilltribe and lowland children has been shown as;

$$Y_{pit} = \beta_0 + \sum_{p=1}^{2} \beta_{1p} X_{pit} + \beta_2 t + \sum_{k=1}^{K} \beta_{3pk} Z_{pikt} + \sum_{m=1}^{M} \beta_{4pm} G_{pim} + C_{pit} + \varepsilon_{pit} \quad (2.5)$$

where Y_{pit} are observations for subject i at time t for each responses; weight for age, length for age, head circumference for age, and ponderal index. β_0 is the intercept, X_{pit} is the group variable, hilltribe or lowland, for subject i at time t, β_{1p} is the regression coefficient for group p, t is time, β_2 is the regression coefficient for time, Z_{pikt} is the time-dependent covariate k for subject i in group p at time t, β_{3pk} is the regression coefficient for time-dependent covariate k, K is the number of time-dependent covariates, G_{pim} is the time-independent covariate m for subject i in group p, β_{4pm} is the regression coefficient for time-independent covariate m, M is the number of time-independent covariates, C_{pit} is the working correlation structure, and ε_{pit} is the error for subject i in group p at time t.

The longitudinal study with repeat measures of weight, length, and head circumference in children less than 18 month are the routine immunizations in Mae Chan Hospital. Hence, this study will construct GEE model for growth pattern of hilltribe and lowland children. We will consider the growth pattern of both groups and also find the factors that effect to their growth.

2.4. Conceptual Framework

From reviewing of the literatures, this study summarized all important factors affecting the growth pattern of lowland and hilltribe children in the following conceptual framework.

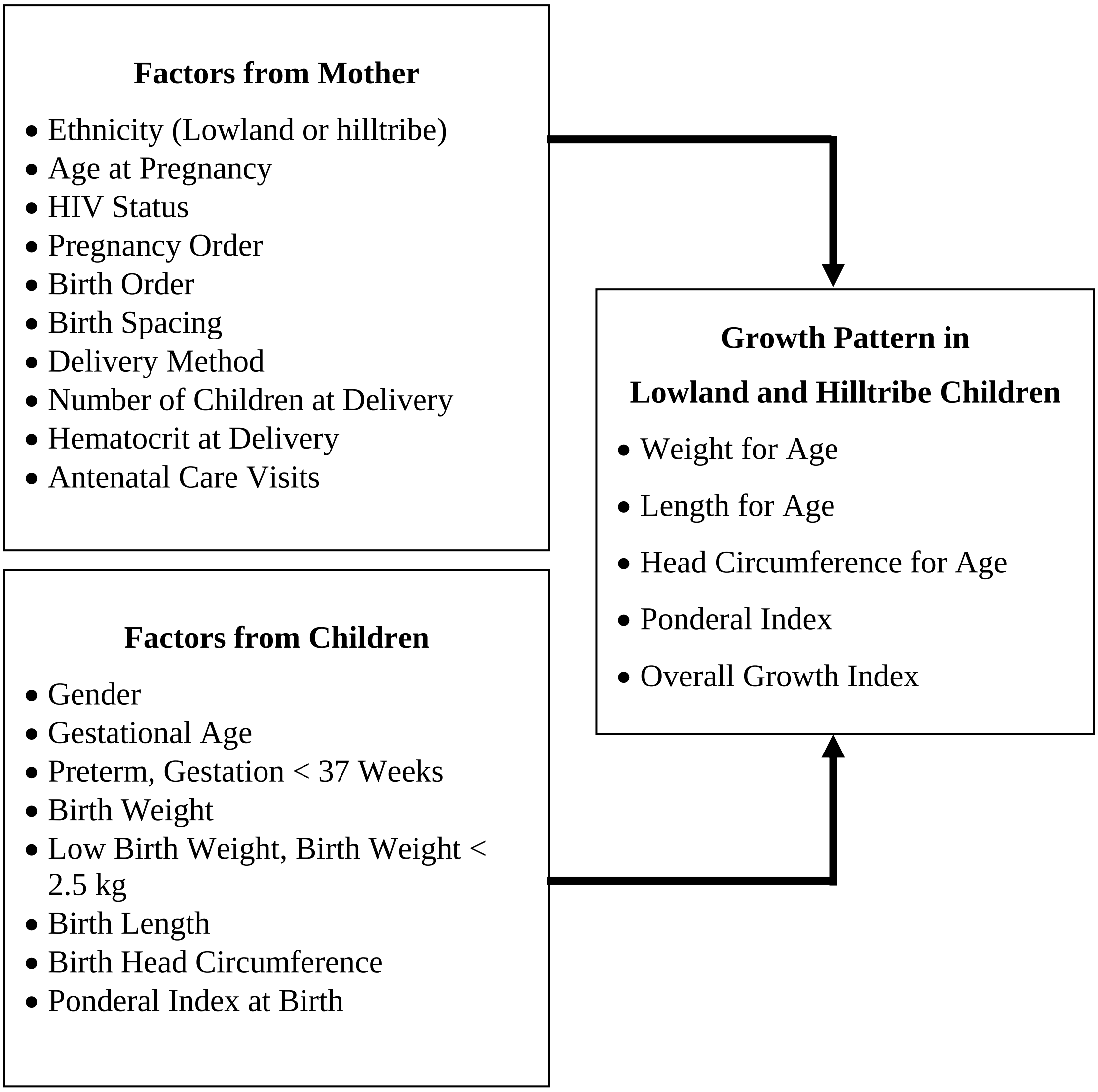

Figure 2.1 Conceptual Framework

CHAPTER III
METHODOLOGY

3.1. Study Design

Longitudinal retrospective cohort study started recruitment period since January 1, 2001 to December 31, 2004, and follow up period start from July 1, 2002 to June 30, 2006. The individuals are routinely measured repeatedly 5 times from routine immunization schedule through 18-month time; at 2, 4, 6, 9, and 18 month of age. The examples of data collection were shown in Figure 3.1.

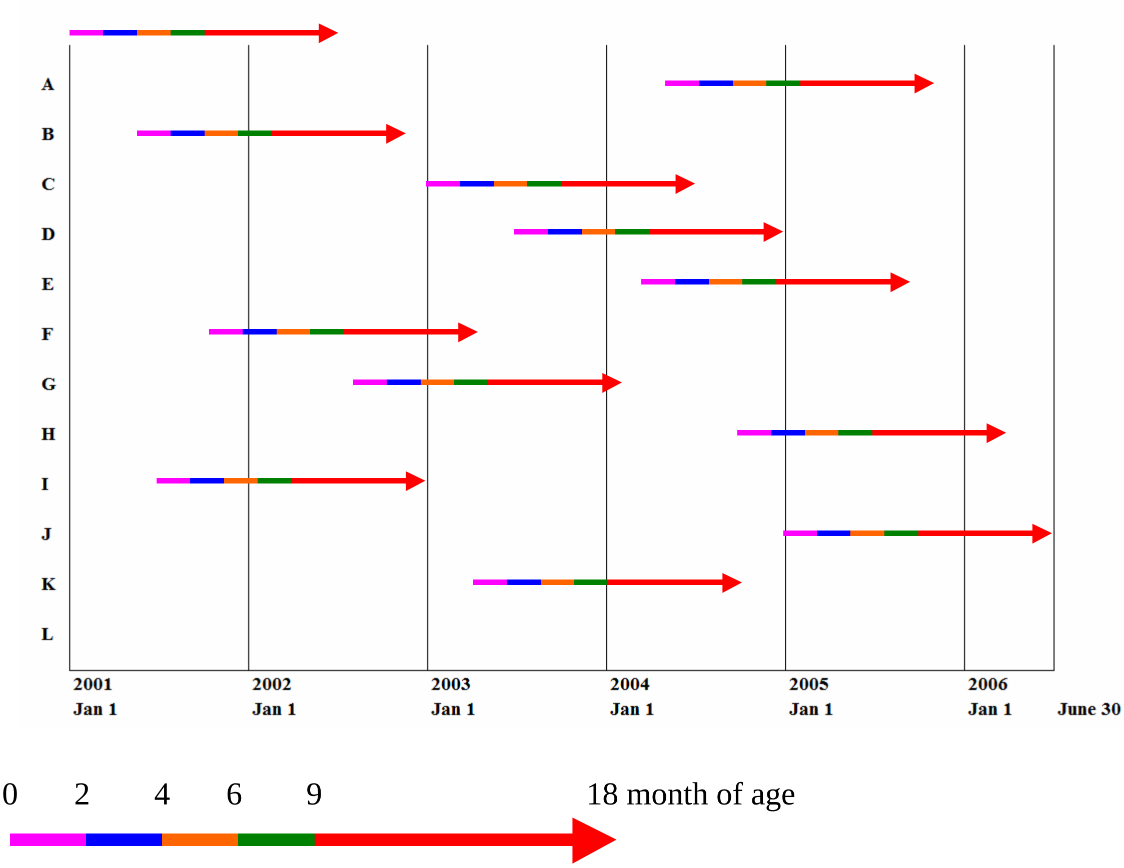

Figure 3.1 Longitudinal Retrospective Cohort Study with Follow-up Measurements

3.2. Study Population

There are 4,101 newborns in Mae Chan Hospital between years 2001-2004. The study population is the birth cohort in Mae Chan Hospital defined as children who were born between years 2001-2004, and their mother are resided in Mae Chan District, Chiang Rai Province. There are 2,425 newborns after excluded children born to mother who are not resident in Mae Chan District. From this amount, 25 percent is hilltribe. Children will separate into two groups, hilltribe and lowland children, by using ethnicity in maternal record from delivery registration.

3.3. Sample Size

Sample size will calculate from formula derived by Twisk J.W.R. (2003: 281), based on GEE approach. The purpose of the study is to compare the development in the continuous outcome variable along the total follow-up period. The equations can be adjusted with an indication of the correlation between the repeated measurements as follows:

$$N = \frac{\left(Z_{(1-\alpha/2)} + Z_{(1-\beta)}\right)^2 \sigma^2 (r+1)\left[1+(T-1)\rho\right]}{v^2 rT} \qquad (3.1)$$

where N is the sample size in both of hilltribe and lowland groups, r is the ratio between the control (lowland) size and the study (hilltribe) size, $Z_{(1-\alpha/2)}$ is the $(1-\alpha/2)\times 100\%$ percentile point of the standard normal distribution, $Z_{(1-\beta)}$ is the $(1-\beta)\times 100\%$ percentile point of the standard normal distribution, σ is the standard deviation of the outcome variable, T is the number of follow-up measurements, ρ is the correlation coefficient of the repeated measurements, and v is the difference in mean value of the outcome variable between two groups.

In pilot study, there were 120 children including; 70 lowland and 50 hilltribe children. The outcome variables were weight for age, length for age, head circumference for age, and ponderal index. For instance, the sample size calculation from weight was conducted in this part. Information needed to perform a power analysis for this study as follows; N was an average sample size at 2, 4, 6, 9, and 18-month follow-up measurements, standard deviation (SD), as an estimate of σ, was an average standard deviation of weight for age at 2, 4, 6, 9, and 18-month follow-up measurement, SD = 1.02, r was the ratio of the number of subjects in lowland children, r = 1.5, T was the number of follow-up measurements, T = 5, ρ was the correlation between follow-up measurement, ρ = 0.25, and v was the difference in mean value of the outcome variable between lowland and hilltribe children, v = 0.34. With a significance level of 5% and a power of 80%, the sample size was calculated.

$$N = \frac{(1.96+0.84)^2(1.02)^2(1.5+1)[1+(5-1)(0.25)]}{(-0.37)^2(1.5)(5)} \quad = 40$$

Sample size of lowland children	= 40*(1/(1+1.5))	= 24
Sample size of hilltribe children	= 40*(1.5/(1+1.5))	= 16

Based on Equation (3.1) a sample size table can be constructed with various within-subject correlation coefficients (ρ) as in Table 3.1.

However, in this study, there are 2,425 newborns after excluded children born to mother who are not resident in Mae Chan District. The sample will include all of children who meet criteria and possible for data collection. Thus, sample size was 2,425 children, and 25% is hilltribe. According to these conditions, there is enough sample size to consider the comparison of growth pattern between hilltribe and lowland children with statistically significant on a 5% level and a power more than 80%. Finally, the actual sample size could be collected was 1,028 children. There were 715 for lowland and 313 for hilltribe children. The data was not complete because of loss data and could not found children in specified address.

Table 3.1 Sample Sizes of the Five Repeated Measurements from Pilot Study of Four Continuous Outcome Variables Comparison between Two Groups Statistically Significant on a 5% Level with a Power of 80%; Studies with Different Within-subject Correlation Coefficients (ρ).

Outcome Variables	ρ	Lowland	Hilltribe	Total
Weight for Age	0.25	24	16	40
	0.50	36	24	60
	0.75	48	32	80
Length for Age	0.25	1,613	1,075	2,688
	0.50	2,419	1,613	4,032
	0.75	3,226	2,151	5,377
Head circumference for Age	0.25	2,025	1,350	3,375
	0.50	3,037	2,050	5,087
	0.75	4,049	2,699	6,748
Ponderal Index	0.25	51	34	85
	0.50	76	51	127
	0.75	102	68	170

3.4. Data Collections

Name list of all children born in Mae Chan Hospital between years 2001-2004 was listed from delivery registration. From health service system, the routine immunizations for children will take the response by hospital and health center depending on area and number of population. Mae Chan Hospital is responsible for immunizations of children living in Mae Chan sub-district only. And there are 16 sub-district health centers where are responsible for other 10 sub-districts. The researcher will collect data of children living in Mae Chan Sub-district from the record in Mae Chan Hospital. For other sub-districts, the list will be separated by area, sent to sub-district health center's staff for data collection.

Children data were collected from medical records in OPD card of Mae Chan Hospital and immunization records were also collected from sub-district health centers. Routine growth monitoring is a core component of maternal and child health services in many countries. In early infancy, clinic visits for routine immunizations provide the opportunity for anthropometric raw measures. At birth, 2, 4, 6, 9, and 18 month of age, weight, length, and head circumference of childhood will be measured. In addition, maternal data were obtained from medical records at delivery in antenatal care clinic. Data collection sheet was used for all data entry and data analysis.

Database included in the following items:

1) Neonatal factors were included gender, gestational age, birth weight, birth length, birth head circumference, and ponderal index at birth; and

2) Maternal factors were included age at pregnant, parity, delivery method, pregnancy order, children order, birth spacing, number of children at delivery, HIV status, hematocrit, and number of antenatal care visits.

In addition, weight, length, and circumference were measured at every visit for immunization, scheduled at 2, 4, 6, 9, and 18 month of age. These measures were use to evaluate the growth of childhood.

Ethical approval was obtained from the Mahidol University Ethical Committee and the informed consent was obtained prior to director of Mae Chan Hospital and head of Mae Chan District Health Office.

3.5. Statistical Analysis

The statistical methods used in this study included descriptive statistics, and Generalized Estimating Equations (GEE).

Descriptive statistics were used to describe general characteristics of lowland and hilltribe children. Number and percentage were used to describe the characteristics of category variables, such as of neonatal gender, term of delivery (term/preterm), low birth weight, maternal HIV status, parity, delivery method, etc. In addition, number of subjects, mean, standard deviation, minimum, and maximum were used to describe characteristics of continuous variables, such as gestational age, birth weight, maternal age at pregnancy, etc. Otherwise, the comparison between lowland and hilltribe children, such as chi-square test was used to compare the differences in proportions for category variables. The student t-test or Mann-Whitney U test was used to compare for continuous variables.

GEE analyses were used to construct model for growth pattern of hilltribe and lowland children. As a calculation like regression method, the GEE coefficients reflected the relationships between the predictor variables and the dependent variables throughout the longitudinal period. In an univariate GEE analysis, the model will show roughly the association between outcome variables and each predictor variable. The multivariate GEE will be considered from the significant predictor variable from the univariate analysis. The final model is the last adjusted model, which shows the least standard deviation or the least number of the predictor variables.

CHAPTER IV
RESULTS

The results in this study will explain as following topics.

4.1. Data for Analysis

4.2. Characteristics of Lowland and Hilltribe Children

4.3. Weight, Length, and Head Circumference Comparisons with Thai Children

4.4. Growth Index Conducting

4.5. Within-subject Correlation Consideration

4.6. Univariate GEE Analysis

4.7. Multivariate GEE Analysis

4.1. Data for Analysis

The children born in Mae Chan Hospital between years 2001-2004 were listed from delivery registration by using hospital number (HN). The total of newborns was 4,101. There were 2,425 newborns whose mothers have resided in Mae Chan District, Chiang Rai Province. From this amount, 25 percent is hilltribe. Children were separated into two groups, hilltribe and lowland children, by using ethnicity in maternal record from delivery registration. There were 2,039 newborns that were found medical records or OPD card, only 1,475 newborns had named. Maternal and neonatal data at delivery were collected in data collection form. So, 1,475 children who had data at delivery were listed for finding pattern of growth indices from immunization record or “Mother and Child’s Health Handbook”. From health service system, hospitals and health centers take response for the routine immunizations for children depending on area and number of populations. Mae Chan Hospital was responsible for immunizations of children living in Mae Chan Sub-district only. In addition, other 10 sub-districts were responded by health centers. The data of children living in Mae Chan Sub-district were collected from immunization record in OPD card in Mae Chan Hospital, linked by HN. For other sub-districts, the children names were separated by area and made a list. The list was sent to sub-district health center's staffs, after that growth data collected from medical record for immunization or "Mother and Child's Health Book". From 2,425 newborns who were met the inclusion criteria, there were 42 percent of children could get growth information and 58 percent was lost information.

However, there were many reasons for incomplete growth data. For instance, there are 353 newborns could not found OPD card. While 564 newborns could found OPD card but no recording name in OPD card, so these children could not found more information. Another reason is that the health center staffs could not find the children's name in community or they could find the children's name but could not get any information at growth. Furthermore, some children did not receive the immunization from health center but they go to private clinic or private hospital or government hospital located in another district, these children did not have any growth information in health center in Mae Chan District.

In conclusion, 1,028 children who were born in Mae Chan Hospital between years 2001 to 2004 and mother living at Mae Chan District, Chiang Rai Province were recruiting in this analysis. Thirty percent was hilltribe children. For data management, data would kept in 2 databases, the first database included data at birth that were time-independent variables;

1) Neonatal factors; gender, gestational age, birth weight in kilogram, birth length in centimeter, birth head circumference in centimeter, and ponderal index at birth (kg/m^3); and

2) Maternal factors; age at pregnancy, pregnancy order, birth order, birth spacing in year, number of children at delivery, delivery method, HIV status, hematocrit (HCT) in percentage, and number of antenatal care visit (ANC), which effect to infant growth.

For time-dependent variable, neonatal HIV status was excluded because of confidential issue. This data was kept by using maternal name for identification, and did not allow for distribution. In second database that outcome variables were including, contained visit date, weight in kilogram (kg), length in centimeter (cm), and head circumference in cm at every visit for immunization. However, in many longitudinal studies, subjects were followed over a period of time and were scheduled to assess at a common set of prespecified visit times after enrollment. Similarly, in this study, many subjects selectively missed their visits or returned at non-scheduled points in time. As a result, the measurement times were irregular, yielding a highly imbalanced data structure. In addition, the frequency and timing of the visits might be correlated with the longitudinal outcomes. Then the visit months would calculated from the difference between birth date and visit date, coded as 1, 2, 3, …, 19 months. Furthermore, visit month would be the time variable in this analysis. All variables were explained in Table 4.1

Table 4.1 Database and Variables

Variable Name	Scale	Description	Dummy
I. <u>Data at Birth</u>			
SAMPLEID	Interval	Identification number for children	-
HILLTRIBE	Nominal	Neonatal ethnicity defined by maternal ethnicity	0 = Lowland children 1 = Hilltribe children
FEMALE	Nominal	Neonatal gender	0 = Male 1 = Female
GESTATION	Ratio	Gestational age (weeks)	-
PRETERM	Nominal	Preterm at birth (gestational age<37weeks)	0 = No 1 = Yes
BWKG	Ratio	Birth weight (km.)	-
LOWBW	Nominal	Birth weight <2.5 kg.	0 = No 1 = Yes
BLT	Ratio	Birth length (cm.)	-
BPONDERAL	Ratio	Ponderal index at birth (kg/m^3)	-
BHEAD	Ratio	Birth head circumference (cm.)	-
PREGORDER	Interval	Pregnancy order	-
MULTIPREG	Nominal	Multiple pregnancy	0 = No 1 = Yes
CHILDORDER	Interval	Order of children	-

Table 4.1 Database and Variables (Continued)

Variable Name	Scale	Description	Dummy
PARITY	Nominal	Order of children	0 = 1^{st} order 1 = not 1^{st} order
BIRTHSPACE	Ratio	Birth spacing from previously pregnancy (years)	-
CHILDNO	Interval	Number of children at birth	-
DELIVER1	Nominal	Deliver by cesarean section, normally delivery defined as reference	0 = No 1 = Yes
DELIVER2	Nominal	Deliver by other methods such as vacuum extraction, forceps extraction, breech birth assisting	0 = No 1 = Yes
AGEMOM	Interval	Maternal age (years-old)	-
AGEMOM1	Nominal	Maternal age 20-29 years-old, age < 20 years-old defined as reference	0 = No 1 = Yes
AGEMOM2	Nominal	Maternal age 30-39 years-old, age < 20 years-old defined as reference	0 = No 1 = Yes
AGEMOM3	Nominal	Maternal age $\geq$ 40 years-old, age < 20 years-old defined as reference	0 = No 1 = Yes
HIVMOMPOS	Nominal	Maternal HIV status	0 = Negative 1 = Positive
HCT	Ratio	Maternal HCT (%)	-
ANCTIME	Interval	The number of antenatal care visits (times)	-
II. <u>Growth Data</u>			
SAMPLEID	Interval	Identify number for children	-
VISITDATE	Interval	Visiting date for immunization	-
VISITMONTH	Interval	Visiting month calculated from period between visit date and birth date (month). Thus the visit month would code as 1, 2, 3, …, 18, 19.	-
WT	Ratio	Weight (kg.)	-
LT	Ratio	Length (cm.)	-
HEAD	Ratio	Head circumference (cm.)	-
PONDERAL	Ratio	Ponderal index (kg/m^3)	-

4.2. Characteristics of Lowland and Hilltribe Children

Table 4.2 summarizes general characteristics of independent variables between lowland and hilltribe children. Also number, percentage, and p-value of Chi-Square, t-test, U-test were shown in the Table 4.2. The chi-square test was used to compare differences in proportions. The student t-test or Mann-Whitney U test used to compare continuous variables.

Table 4.2 Characteristics of Independent Variables among Lowland and Hilltribe Children

Characteristics	Lowland Children		Hilltribe Children		p
	n=715	%	n=313	%	
Gender					0.368
Male	385	53.8	159	50.8	
Female	330	46.2	154	49.2	
Gestational Age (weeks)					
n	*683*		*292*		0.806
Mean	*39*		*39*		
SD	*1.82*		*1.80*		
Minimum	*30*		*30*		
Maximum	*46*		*46*		
Term (≥ 37 weeks)	635	93.0	274	93.8	0.623
Preterm (< 37 weeks)	48	7.0	18	6.2	
Birth Weight (kg.)					
n	*703*		*307*		0.182
Mean	*3.09*		*3.11*		
SD	*0.40*		*0.41*		
Minimum	*1.65*		*1.1*		
Maximum	*4.8*		*4.1*		
Normal weight (>=2.5 kg.)	665	94.6	292	95.1	0.733
Low birth weight (<2.5 kg.)	38	5.4	15	4.9	

Table 4.2 Characteristics of Independent Variables among Lowland and Hilltribe Children (Continued)

Characteristics	Lowland Children		Hilltribe Children		p
	n=715	%	n=313	%	
Birth Length (cm.)					0.121
n	*704*		*309*		
Mean	*50.8*		*51.0*		
SD	*3.15*		*3.37*		
Minimum	*30*		*31*		
Maximum	*65*		*58*		
Birth Head Circumference (cm.)					0.002**
n	*707*		*310*		
Mean	*32.4*		*32.7*		
SD	*2.39*		*2.56*		
Minimum	*26*		*27*		
Maximum	*57*		*53*		
Ponderal Index at Birth (kg/m^3)					0.747
n	*700*		*306*		
Mean	*24.0*		*23.9*		
SD	*7.31*		*7.59*		
Minimum	*12.0*		*14.5*		
Maximum	*109.9*		*100.7*		
Maternal Age at Pregnancy (years)					0.381
n	*712*		*311*		
Mean	*25.4*		*25.1*		
SD	*6.29*		*6.35*		
Minimum	*14*		*14*		
Maximum	*46*		*44*		
Maternal Age Group (years)					0.555
< 20	129	19.0	62	20.7	
20-29	368	54.3	161	53.8	
30-39	167	24.6	66	22.1	
≥ 40	14	2.1	10	3.3	

Table 4.2 Characteristics of Independent Variables among Lowland and Hilltribe Children (Continued)

Characteristics	Lowland Children		Hilltribe Children		p
	n=715	%	n=313	%	
Pregnancy Order					<0.001**
n	*702*		*303*		
Mean	*2*		*2*		
SD	*0.94*		*1.55*		
Minimum	*1*		*1*		
Maximum	*9*		*11*		
1	325	46.3	92	30.4	<0.001**
>1	377	53.7	211	69.6	
Birth Order (alive at birth only)					
n	*649*		*265*		<0.001**
Mean	*2*		*2*		
SD	*0.71*		*1.41*		
Minimum	*1*		*1*		
Maximum	*6*		*9*		
Nulliparous	353	54.4	99	37.4	<0.001**
Parous	296	45.6	166	62.6	
Birth Spacing (years)					<0.001**
n	*338*		*188*		
Mean	*6.4*		*4.2*		
SD	*4.12*		*2.94*		
Minimum	*1*		*0.8*		
Maximum	*20*		*17*		
Number of Children at Delivery					0.006**
1	710	99.3	304	97.1	
>1	5	0.7	9	2.9	
Delivery Method					0.007**
Normal delivery	555	79.6	255	83.1	
Cesarean section	128	18.4	38	12.4	
Others	14	2.0	14	4.6	
Maternal HIV Status					0.155
Negative	685	96.3	300	98.0	
Positive	26	3.7	6	2.0	

Table 4.2 Characteristics of Independent Variables among Lowland and Hilltribe Children (Continued4)

Characteristics	Lowland Children		Hilltribe Children		p
	n=715	%	n=313	%	
Maternal HCT (%)					0.139
n	*713*		*313*		
Mean	*45.7*		*46.6*		
SD	*22.96*		*24.35*		
Minimum	*6*		*26*		
Maximum	*100*		*100*		
ANC Visits (times)					<0.001**
n	*665*		*283*		
Mean	*9.5*		*7.6*		
SD	*3.32*		*3.20*		
Minimum	*1*		*1*		
Maximum	*19*		*16*		

** Significant level at 0.05.
The difference in proportions was test by χ^2 -test, the difference of mean was test by student t-test or Mann-Whitney U-test.

According to Table 4.2, there were 715 lowland and 313 hilltribe children were recruiting in the analysis, half of them were male. Mean of gestational age in both groups were 39 weeks. The percentage of those who were born preterm (gestational age<37 weeks) was relatively low between lowland and hilltribe children, 7.0 and 6.2 percent, respectively. Mean birth weight of lowland and hilltribe chidren were 3.09 and 3.11 kilograms, respectively. Only 5.4 and 4.9 percent between lowland and hilltribe chidren were have low birth weight (<2.5 kg). Mean birth length in centimeter, mean birth head circumference in centimeter, and mean ponderal index at birth (birth weight in kilogram/birth length in meter^3) were 51 cm, 24 cm, and 24 kg/m^3, respectively. There were not differences in birth weight, length, and ponderal index between two groups of children. In the other hand, birth head circumference was significant difference (p=0.002). Mean maternal age at pregnancy was 25 years old and was not significant difference. However, if group of maternal age at pregnancy were considered as 4 categories, less than 20 years old, 20-29 years-old, 30-39 years-old, and more than and equal 40 years-old. It also was not significant difference between maternal age group. Pregnancy order was significant difference (p<0.001). Hilltribe children born to mother who had been pregnant more than one time was 53.7 percent, while it was 69.6 percent among lowland children. Most of children were not the first children. Birth spacing from previously birth order was significant difference (p<0.001). Mean birth spacing were 6.4 and 4.2 years among lowland and hilltribe children, respectively. Almost of them were single birth but this was significant difference between both groups of children (p=0.006), only 0.7 and 2.9 percent among lowland and hilltribe children were multiple birth. For delivery method, 79.6 percent delivered normally, and 18.4 percent delivered by cesarean section among lowland children, while 83.1 and 12.4 percent among hilltribe children, respectively. There was significant difference in delivery method (p=0.007). Children who were born to HIV positive mother were 3.7 and 2.0 percent among lowland and hilltribe, respectively. Mean maternal HCT were 45.7 and 46.6 percent among lowland and hilltribe children, respectively. ANC visiting time were significant difference (p<0.001), mean of ANC visits were 9.5 and 7.6 times among lowland and hilltribe children, respectively.

In conclusion, the characteristics of lowland and hilltribe children in this study were not so different. Neonatal gender, gestational age, birth weight, birth length, ponderal index at birth, maternal age at pregnancy, maternal HIV status, and maternal HCT were similarly among both groups. However, there were some factors that were different; birth head circumference, pregnancy order, birth order, birth spacing, number of children at delivery, delivery method, and ANC visits.

The characteristics of outcome variables among lowland and hilltribe children categorized by children's age were summarized in Table 4.3. According to weight, length, and head circumference were measured for immunization schedule at 2-, 4-, 6-, 9-, and 18-month of age. All outcome variables were considered by neonatal age compared between lowland and hilltribe children as showed in Table 4.3. Aged 1-3 month, weight and ponderal index were significant differences (U-test) in both groups at significant level 0.05. At aged 4-5 month, only ponderal index was significant difference (t-test). Whereas at aged 6-7 month, head circumference and ponderal index were significant differences (t-test). At aged 8-10 month, length and ponderal index were significant differences (t-test). In addition, weight and length between both groups of children in aged 17-19 month were significant differences (U-test and t-test respectively).

Table 4.3 Characteristics of Outcome Variables among Lowland and Hilltribe Children

Variables		Lowland Children	Hilltribe Children	p
At Age (VISIT MONTH) 1-3 Months				
Weight (kg.)	n	502	224	0.027*
	Mean	5.5	5.6	
	SD	0.91	0.92	
	Minimum	2.8	3.0	
	Maximum	8.5	8.5	
Length (cm.)	n	370	138	0.944
	Mean	57.2	57.5	
	SD	4.29	3.85	
	Minimum	37.0	39.0	
	Maximum	70.0	68.0	
Head Circumference (cm.)	n	150	68	0.068
	Mean	38.7	39.1	
	SD	1.61	1.72	
	Minimum	34.0	33.0	
	Maximum	42.0	43.0	
Ponderal Index at Birth (kg/m3)	n	367	137	0.005*
	Mean	29.6	30.4	
	SD	9.15	7.90	
	Minimum	14.9	15.9	
	Maximum	128.3	104.5	
At Age (VISIT MONTH) 4-5 Months				
Weight (kg.)	n	474	209	0.080
	Mean	6.9	7.0	
	SD	0.93	1.01	
	Minimum	4.1	4.7	
	Maximum	10.2	10.0	

Table 4.3 Characteristics of Outcome Variables among Lowland and Hilltribe Children (Continued)

Variables		Lowland Children	Hilltribe Children	p
Length (cm.)	n	335	125	0.623
	Mean	62.7	62.6	
	SD	3.52	3.72	
	Minimum	50.0	50.0	
	Maximum	80.0	75.0	
Head Circumference (cm.)	n	137	64	0.160
	Mean	41.1	41.5	
	SD	1.81	1.75	
	Minimum	30.0	33.0	
	Maximum	45.0	45.5	
Ponderal Index at Birth (kg/m3)	n	333	124	0.001*
	Mean	28.0	29.5	
	SD	4.33	4.88	
	Minimum	11.7	14.7	
	Maximum	42.6	44.0	
At Age (VISIT MONTH) 6-7 Months				
Weight (kg.)	n	465	190	0.143
	Mean	7.7	7.8	
	SD	1.10	1.08	
	Minimum	4.0	5.0	
	Maximum	11.0	12.0	
Length (cm.)	n	325	118	0.520
	Mean	66.3	66.2	
	SD	3.59	3.95	
	Minimum	55.0	57.0	
	Maximum	85.0	80.0	
Head Circumference (cm.)	n	132	55	0.011*
	Mean	42.9	43.6	
	SD	1.54	1.55	
	Minimum	39.0	40.0	
	Maximum	48.0	48.0	

Table 4.3 Characteristics of Outcome Variables among Lowland and Hilltribe Children (Continued)

Variables		Lowland Children	Hilltribe Children	p
Ponderal Index at Birth (kg/m3)	n	321	118	0.009*
	Mean	26.5	27.4	
	SD	4.31	4.33	
	Minimum	12.7	13.7	
	Maximum	46.2	39.7	
At Age (VISIT MONTH) 8-10 Months				
Weight (kg.)	n	555	244	0.334
	Mean	8.5	8.6	
	SD	1.12	1.34	
	Minimum	5.0	5.0	
	Maximum	13.0	14.0	
Length (cm.)	n	395	156	0.045*
	Mean	70.5	70.0	
	SD	3.98	4.64	
	Minimum	58.0	56.0	
	Maximum	85.0	92.0	
Head Circumference (cm.)	n	124	49	0.856
	Mean	44.5	44.6	
	SD	1.25	1.69	
	Minimum	42.0	41.0	
	Maximum	48.0	49.0	
Ponderal Index at Birth (kg/m3)	n	390	155	0.010*
	Mean	24.5	25.6	
	SD	4.15	5.72	
	Minimum	11.4	10.1	
	Maximum	41.0	56.9	
At age (VISIT MONTH) 17-19 Months				
Weight (kg.)	n	732	307	<0.001*
	Mean	10.7	10.2	
	SD	1.55	1.59	
	Minimum	6.9	7.0	
	Maximum	19.0	19	

Table 4.3 Characteristics of Outcome Variables among Lowland and Hilltribe Children (Continued)

Variables		Lowland Children	Hilltribe Children	p
Length (cm.)	n	566	223	<0.001*
	Mean	79.9	78.4	
	SD	4.51	4.85	
	Minimum	65.0	65.0	
	Maximum	105.0	100.0	
Head Circumference (cm.)	n	176	76	0.558
	Mean	46.6	46.7	
	SD	1.45	1.69	
	Minimum	42.5	44.0	
	Maximum	51.0	50.0	
Ponderal Index at Birth (kg/m3)	n	565	223	0.122
	Mean	20.9	21.4	
	SD	3.18	3.65	
	Minimum	10.5	10.0	
	Maximum	35.0	43.7	

* Significant level at 0.05

Weight, length, head circumference, and ponderal index by age were representative of general growth, and they provide information on present growth status or any progress. Interpretation of these measurements was, best understood, in healthy children when plotted on growth charts. Growth charts provided an assessment or comparison of how the values of these measurements for an infant compare with the percentile distribution of other infants at the same age for these measures. When growth was measured at repeated visits, the amount of change in a pair of measurements or increments in weight, recumbent length and head circumference from one visit to the next can be quantified. This information was an additional perspective on infant growth and can be used to monitor growth progress. Then growth charts of weight by age, length by age, head circumference by age, and ponderal index by age were shown in Figure 4.1, 4.2, 4.3, and 4.4, respectively.

The percentile curves on these charts represent what percentages of children were of the same growth indicators. The 50th percentile represents the growth indices for each age group. The 10th, 50th, and 90th percentiles values of weight, length, head circumference, and ponderal index were presented by children ethnicity in Figure 4.1, 4.2, 4.3, and 4.4 respectively. Comparisons of weight by age in Figure 4.1, length by age in Figure 4.2, and head circumference by age in Figure 4.3 between lowland and hilltribe children were shown that weight, length, and head circumference were increasing rapidly during the early months of life, and then there were deceleration. The curves were similar in both groups of children, and were not significant differences for all percentiles. Although, ponderal index for age in Figure 4.4 was increasing in first 2 months of age but there were decreasing after 2 months of age. In first ten months of life, ponderal index in hilltribe children was slightly higher than lowland children. After that, lowland children showed ponderal index higher than. However, the pattern plots were similar in both group of children, and were not significant differences for all percentiles.

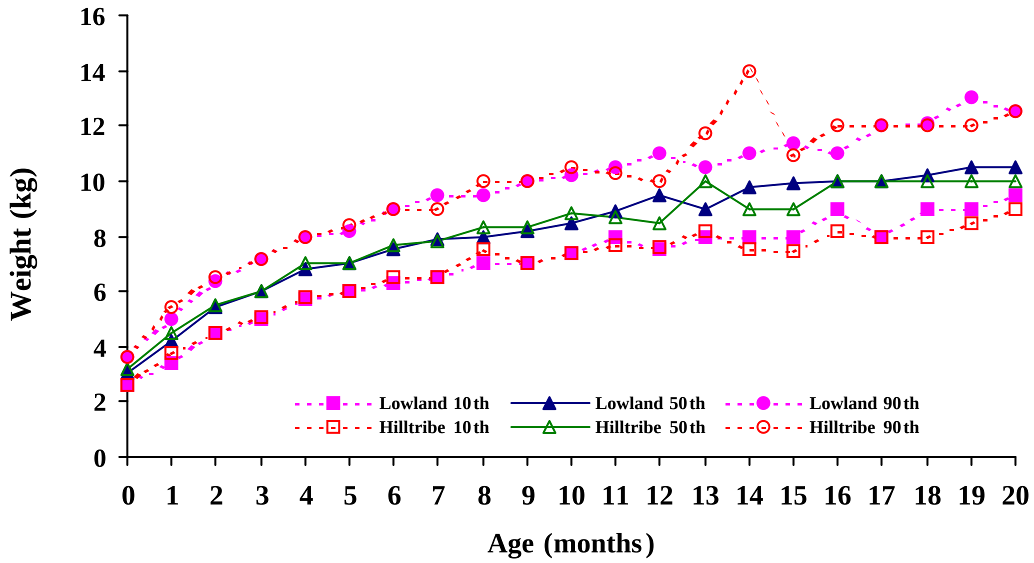

Figure 4.1 Weight by Age at 10th, 50th, and 90th Percentile for Lowland and Hilltribe Children.

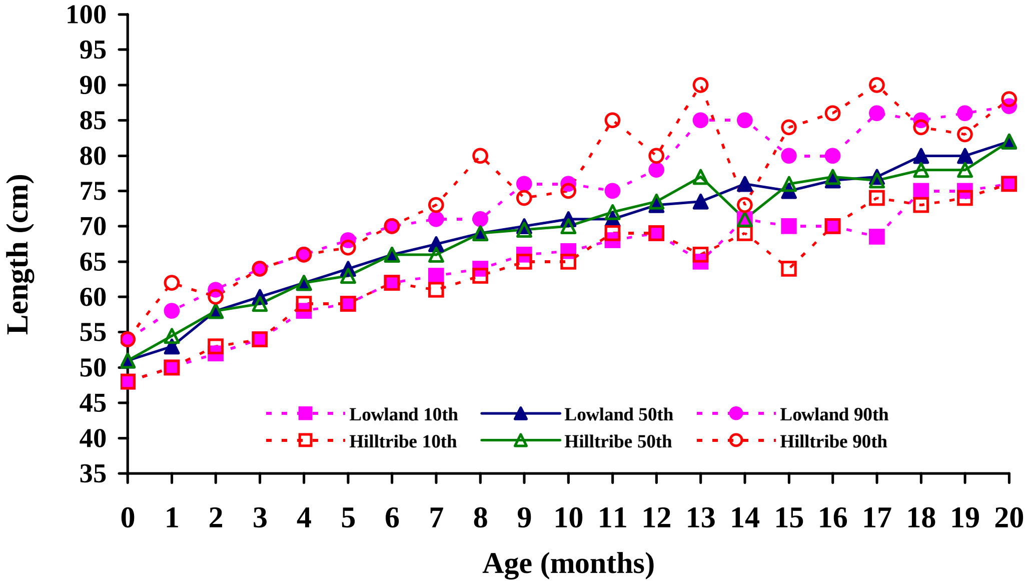

Figure 4.2 Length by Age at 10th, 50th, and 90th Percentile for Lowland and Hilltribe Children.

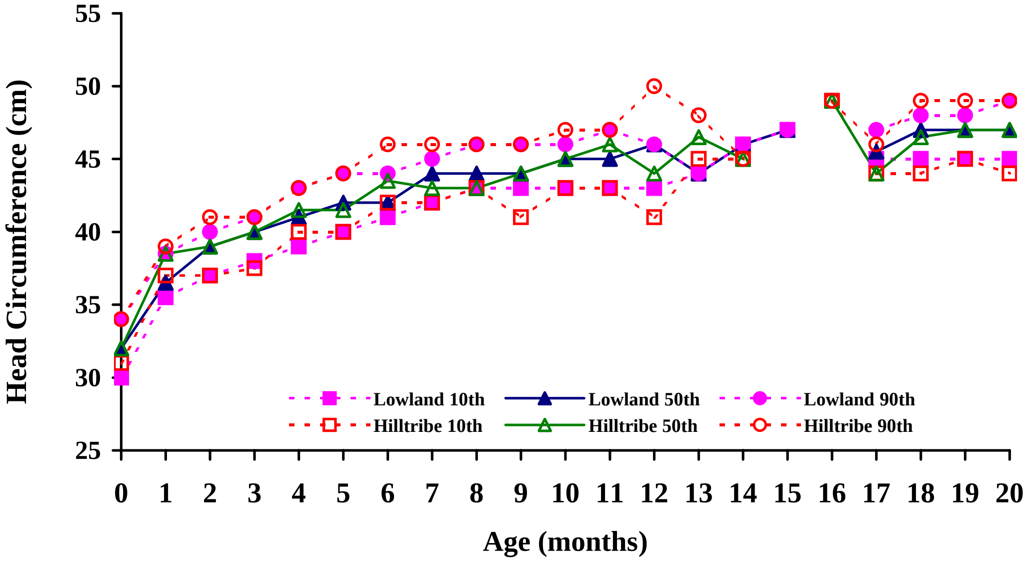

Figure 4.3 Head Circumference by Age at 10th, 50th, and 90th Percentile for Lowland and Hilltribe Children.

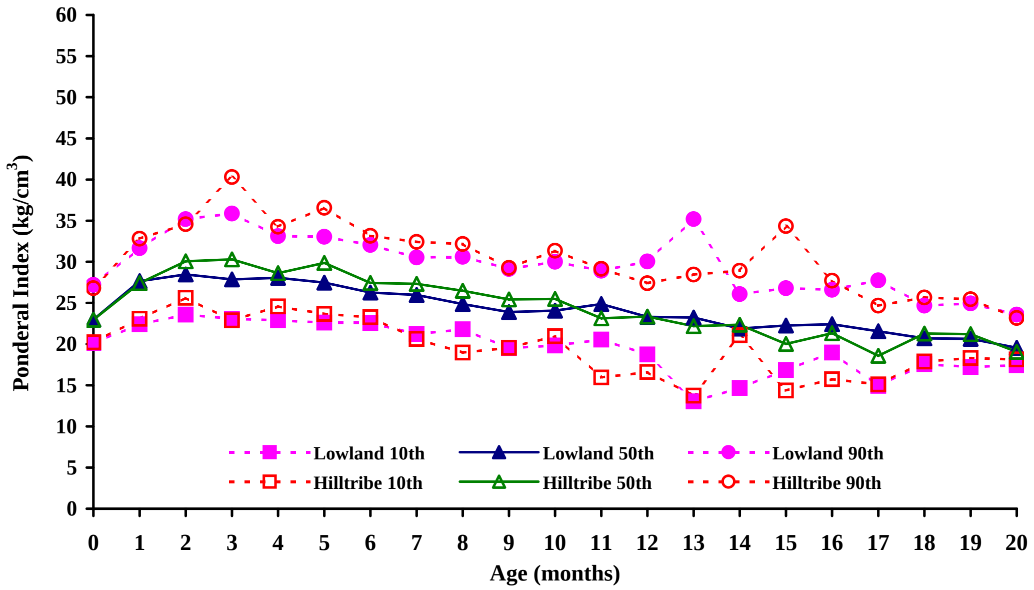

Figure 4.4 Ponderal Index by Age at 10th, 50th, and 90th Percentile for Lowland and Hilltribe Children

4.3. Weight, Length, and Head Circumference Comparisons with Thai Children

During infancy and childhood, there were many important physical and developmental changes that take place, especially in the first year of life. Physical growth, which was generally measured in terms of length, weight and head growth, was also monitored carefully. Because growth and development were telling signs of a child's health, and because the changes occur so rapidly during the first 18 months, the check-ups need to be organized frequently on a regular basis during this important period of your child's life. The anthropometric measurements commonly used as indices of growth and development for infants include weight, length, and head circumference. Anthropometric data, including measurements relating to body composition, had great value in nutritional assessment. Generally, the children growth was evaluated by comparing with the reference group. Growth reference was collected data of weigh or length or head circumference from full growth potential children by using standard measurement method and instrument. There were two references that used for growth of weight, length, and head circumference. (Nutrition Division, Department of Health, Ministry of Public Health, Thailand, 2004.)

1. Local reference is established by each country to evaluate children growth in each country.
2. International reference was the standard reference for children growth, that uses to compare the children growths among countries, i.e. National Center for Health Statistics (NCHS), and child growth standards from World Health Organization (WHO).

In "Guideline of weight, length/height for evaluation child growth standard references in Thailand" by Nutrition Division, Department of Health, Ministry of Public Health, Thailand in year 2004, there were three indices (weight for age, length/height for age, and weight for length/height) that were used for evaluation of the child growth in term of weight and length/height. Each index evaluates child growth in different meaning. Weight measured the growth of all body tissues. Weight for age indicated the relationship between weight gain in any age, this index uses for evaluation problem, e.g. undernutrition, protein-energy malnutrition, underweight, lack of weight gain, overweight. Length/height describes the amount of linear growth, length/height for age were indicated nutrition situation that may occur since prenatal or in uteo. This index will be used to evaluate malnutrition, stunting. Weight for length/height can be indicated wasting even thought real age was not specified and no effects from ethnicity, especially in age 12-24 months after stop breastfed. This index also used to indicate overweight in general.

In this part weight, length, and head circumference of lowland and hilltribe children will be compared with national growth reference of Thailand. The curves of weight, length, and head circumference for age from national growth reference showed median, ± 1.5 SD, and ± 2 SD that corresponded with the population. Weight, length, and head circumference of lowland and hilltribe children were placed or plotted on a growth cure or chart that illustrates the average rate of growth in children within different age groups. Because boys grow at different rates than girls, separate growth curves by gender are used. The growth curves of weight, length, and head circumference by age were graphically presented in Figure 4.5, 4.6, 4.7, 4.8, 4.9, and 4.10, respectively.

According to Figure 4.5, weight by age in male children of both group were not different in first year of life, but weight in male lowland children were slightly more than male hilltribe children during second year of life. Birth weight of both groups were lower than median of national reference of Thailand, nearly –1.5 SD of reference. In first 6 months of life, on average, weight rapidly increasing over the median of reference but still lower than +2 SD. After that weight still increasing but slowly, lower than the median of reference but higher than -1.5 SD. However, there were some different in weight during 17 to 19 months of age, male lowland children were grown better than hilltribe. Mean weight curve showed that in first 9 months of life, among lowland and hilltirbe children, male were normally growth. After that the growth was less than standard.

Weights by age in female children of both groups were not different as showed in Figure 4.6. Birth weights of both groups were nearly to median of the reference. In first 4 months of life, on average, weight rapidly increasing over the median of reference but were still lower than +2 SD. After that weight were still increasing but slowly and more than the median of reference until 9 months of age. Then mean weights were still increasing, lower than the median of reference but more than-1.5 SD subsequently.

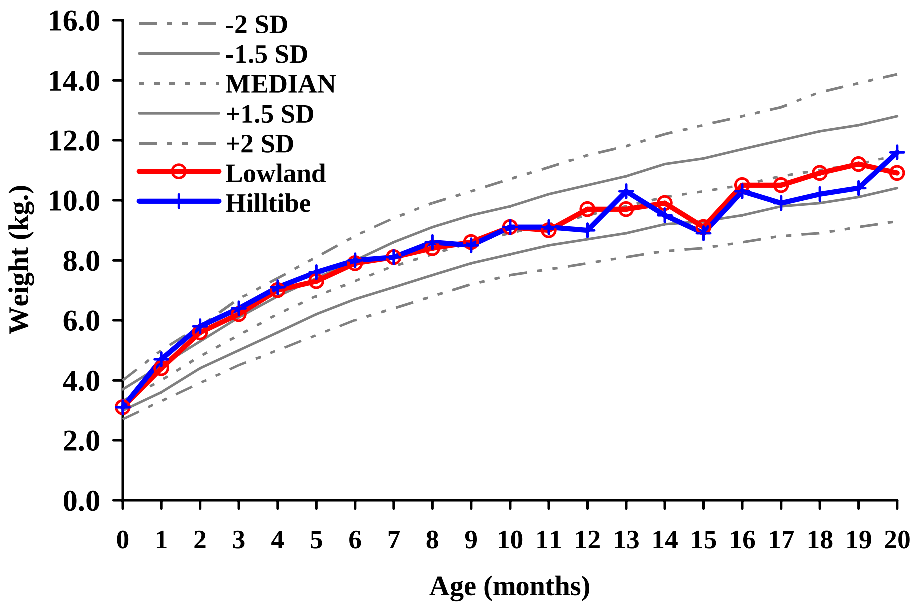

Figure 4.5 Weight by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Male

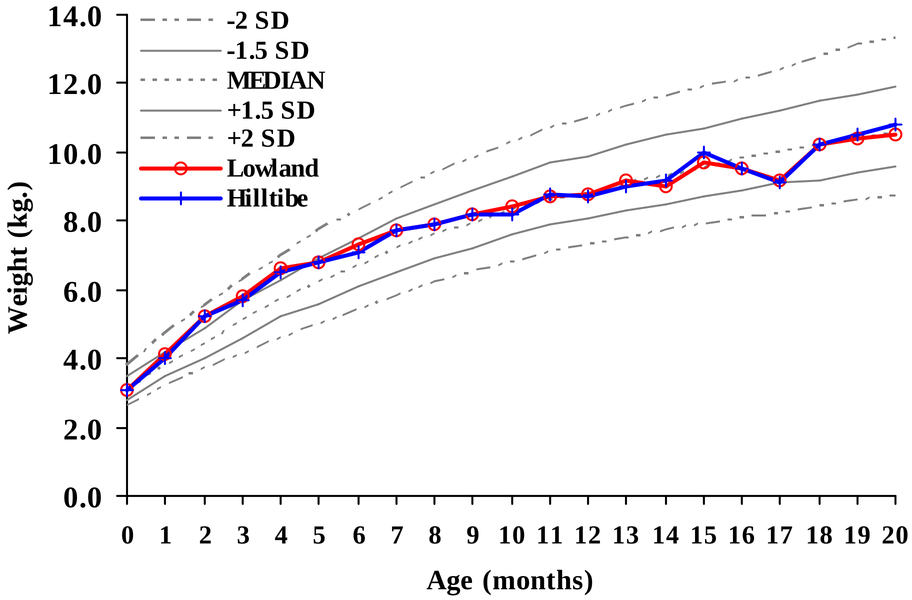

Figure 4.6 Weight by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Female

From Figure 4.7, length by age in male children of both group were slightly different especially after first year of life. Mean birth lengths of both groups were more than median of the reference. In first 9 months of age, mean length in both groups was increasing over the median of reference but was still lower than +2 SD. After that length was still increasing but slowly, lower than the median of reference but more than –1.5 SD. Mean length curve showed that in first 9 months of life, among lowland and hilltirbe children, male were normally growth. After that the growth was less than standard.

As shown in Figure 4.8, lengths by age in female children of both groups were similar in the first 10 months of life but after that were slightly different. Mean birth lengths of both groups were closely to median of the reference. In first 6 months of life, length was increasing but was not differ from the median of reference. Next length still was slowly increasing, lower than the median of reference but was not lower than -1.5 SD. However, length was increasing upper the median of reference during 11 to 13 months of age in hilltribe, 13 to 14 months of age in lowland, respectively. After that length of both group wad decreasing, lower than median but upper than -1.5 SD. After that length was increasing again but still lower than median and upper than –1.5 SD. Mean length curve showed that in first year of life, among lowland and hilltirbe children, female were normally growth. After that the growth was less than standard. However, number of sample who had length measure during 12 to 16 months of age was very small, so the curves were not explained clearly.

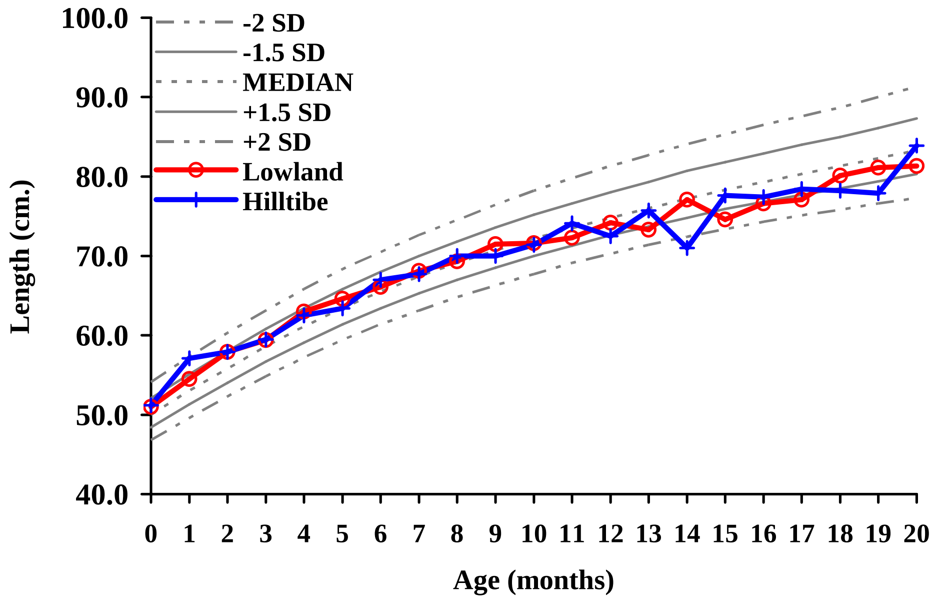

Figure 4.7 Length by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Male

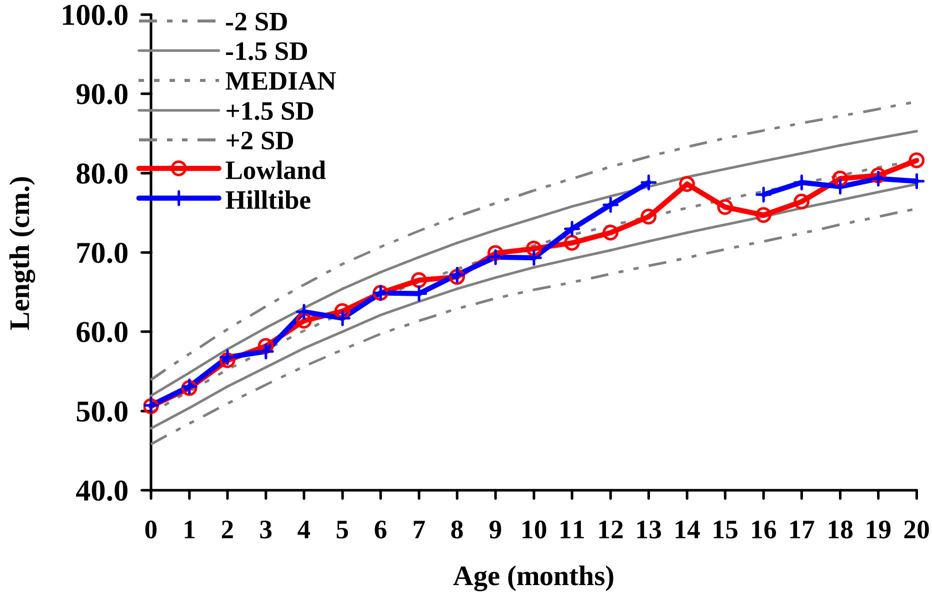

Figure 4.8 Length by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Female

Head circumferences by age of lowland and hilltribe children were shown in Figure 4.9 and 4.10. Number of sample who had head circumference measure was so small, especially after 12 months of age. From this reason, the curves were shown only first year of age. From Figure 4.9 showed that birth head circumferences in male children of both groups were lower than median of the reference, but were rapidly increasing upper than median of reference and also more than +1.5 SD in next 2 months. Subsequently, head circumferences were still increasing but slowly and more than median of reference. However, head circumference in male children of both group were slightly different. In first 2 months, 5 to 7 and after 10 months of age, head circumference of male hilltribe children was more than lowland.

Lastly, head circumferences by age of female lowland and hilltribe children were shown as Figure 4.10. Birth head circumferences in both groups were lower than median of the reference, nearly –1.5 SD. Then there were rapid increasing during first month of age, and still increasing but lowly. After first month of age, head circumferences were more than more than median of the reference, more than +1.5 SD until 8 months of age. Then there were still more than median of the reference, but less than +1.5 SD. On average, head circumference of female hilltribe children was more than lowland.

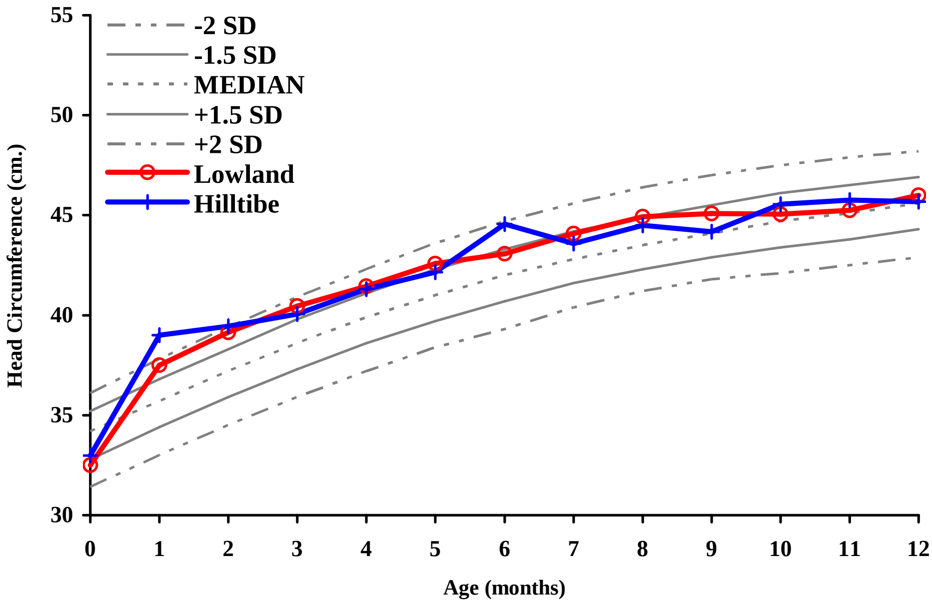

Figure 4.9 Head Circumference by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Male

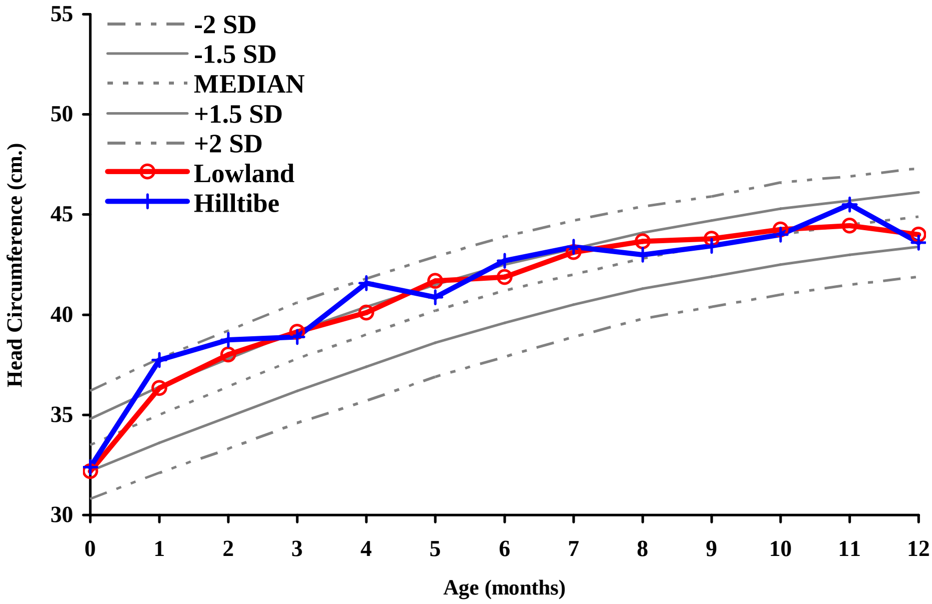

Figure 4.10 Head Circumference by Age Compared between Thai Child Growth Reference and Lowland and Hilltribe Children, Female

4.4. Growth Index Conducting

There were many indices to describe the children growth, for instance, weight, length/height, head circumference, or upper-mid arm circumference (WHO, 1995). The most useful measures of infant growth were weight, recumbent length, and head circumference. Weight measures the growth of all body tissues; recumbent length describes the amount of linear growth, and head circumference reflects brain growth. At birth, the head was disproportionately large compared to the size of the body. In this study, weigh for age, length for age, head circumference for age, and ponderal index were used to be the growth indices among lowland and hilltribe children. However, there was no evidence denote the best growth index in children. So in this study, the new growth indices would be conducted by using exploratory factor analysis. Factor analysis was used primarily as a tool for reducing the number of variables or examining patterns of correlations among variables. The goal of factor analysis was to summarize patterns of correlations among observed variables, to reduce a large number of observed variables to a smaller number of factors. Factor analysis was used to create an entirely new set of variables to partially or completely replace the original set of variables for inclusion in subsequent techniques (Hair, 1998; Kleinbaum, 1998).

In this study, there were five indices to describe growth in children: weight for age, length for age, head circumference for age, ponderal index, and overall growth index. In these indices, weight for age, length for age, and head circumference for age were calculated in term of z-score, which defined as the difference between the value for an individual and the median value of the reference population in Thailand for the same gender and age, divided by the standard deviation of the reference population. Whereas, ponderal index was conducted by relation between weight and length, which calculated as (birth weight (kg))/(birth length (m))^3. Finally, the overall growth index was the new growth index was conducted from weight, length, and head circumference by using factor anaysis.

Regularly, the nutrition intake was important for growth in childhood. Infant in first 6 months of age would drink only breast milk or formula. In next months, only one meal would be added. During 7 to 9 months of age, there were eating two meals with breast milk or formula. Then 10 months of age and later, another one meal would be added. As long as the baby is eating age-appropriate solid foods, a mother might nurse a couple of years if she wishes. A baby needs breast milk for the first year of life, and then as long as desired after that (Damaphong, 2004). Differences food intake in each period of infant's age will effect to growth in each period also. Thus, when new growth index was conducting, factor analysis was illustrated in three parts; aged 1 to 6 months, aged 7 to 9 months and aged more than 9 months. The new index was conducting by using factor analysis as following.

Firstly, there was a visual examination of the correlation between weight, length, and head circumference classified by aged 1 to 6 months, aged 7 to 9 months and aged more than 9 months, identifying those that were statistically significant as shows in Table 4.4. Inspection of the correlation matrix reveals that all correlations were significant at the level 0.05. This provided an adequate basis for proceeding to the next level. The next step was to access the overall significance of the correlation matrix with the Bartlett test, which use for the overall significance of all correlations within a correlation matrix. In this study, the overall correlations were significant at the level 0.05. It was means that the pattern of these correlations was not the nonzero correlations. The other overall test is the measure of sampling adequacy (MSA) by using Kaiser-Meyer-Olkin test, which in this case falls in the unacceptable range (under 0.50). As the MSA values of all groups were over 0.50 indicated that the reduced set of variables collectively meets the necessary threshold of sampling adequacy. Thus these measures all indicated that the reduced set of variables was appropriated for the factor analysis.

Next, the number of components would be selected in further analysis. Table 4.5 contained the information regarding the possible factors and their relative explanatory power as expressed by their eigenvalues. The first factor retained represent 85, 65, and 77 percent of the three variables in aged 1 to 6 months, 7 to 9 months, and more than 9 months, respectively. So the relative of three variables would conduct in one factor for each age group. The factor rotation was not used in this analysis because of the new index was conducted from three growth indices and the result was shown only one factor.

Table 4.4 Correlations among Weight, Length, and Head Circumference

Variable	Correlations among Variables								
	Aged 1-6 months			Aged 7-9 months			Aged > 9 months		
	WT	LT	HEAD	WT	LT	HEAD	WT	LT	HEAD
WT	1.00			1.00			1.00		
LT	0.70**	1.00		0.40**	1.00		0.60**	1.00	
HEAD	0.76**	0.76**	1.00	0.57**	0.40**	1.00	0.61**	0.63**	1.00
Bartlett Test of Sphericity	p<0.001**			p<0.001**			p<0.001**		
Measure of Sampling Adequacy	0.76			0.66			0.72		

** Significant level at 0.05.

Table 4.5 Results for the Extraction of Component Factors

Factor	Component Factors								
	Aged 1-6 months			Aged 7-9 months			Aged > 9 months		
	Eigen	%Var.	Cum%	Eigen	%Var.	Cum%	Eigen	%Var.	Cum%
1	2.54	84.53	84.53	1.95	65.04	65.04	2.32	77.27	77.27
2	0.25	8.28	92.81	0.62	20.74	85.79	0.41	13.74	91.01
3	0.22	7.19	100.00	0.43	14.22	100.00	0.27	8.99	100.00

Eigen = Eigenvalue, %Var. = Percent of Variance, Cum% = Cumulative Percent of Variance

Table 4.6 showed factor loadings in each variable on the factor, which explained weight of each variable in the factor. The communality was summary statistics detailing how well each variable was explained by this factor. It was means that at aged 1 to 6 months the new factor could explain WT, LT, and HEAD for 85, 85, and 83 percent, respectively. Whereas, at aged 7 to 9 months the new factor could explain WT, LT, and HEAD for 71, 56, and 68 percent, respectively. Lasting, at aged more than 9 months the new factor could explain WT, LT, and HEAD for 79, 81, and 72 percent, respectively.

Table 4.6 Component Factor Analysis

Variables	Aged 1-6 months		Aged 7-9 months		Aged > 9 months	
	Factor Loading	Communality	Factor Loading	Communality	Factor Loading	Communality
WT	0.924	0.853	0.845	0.714	0.890	0.793
LT	0.922	0.849	0.748	0.559	0.900	0.809
HEAD	0.913	0.833	0.824	0.678	0.846	0.716

Finally, the new index of child aged under 18 months was conducting from weight, length, and head circumference, called “Overall Growth Index” and variable named “ALLGROWTH”, that was calculated by age group from factor scores. These factor scores were extracted from the principle component analysis with no rotation as follows.

(a) Aged 1 to 6 months:

$$ALLGROWTH = (0.364*WT) + (0.363*LT) + (0.360*HEAD)$$

(b) Aged 7 to 9 months:

*ALLGROWTH = (0.433*WT) + (0.383*LT) + (0.422*HEAD)*

(c) Aged 10 to 18 months:

*ALLGROWTH = (0.384*WT) + (0.388*LT) + (0.365*HEAD)*

This new outcome variable for growth indices would be included in the univariate and multivariate GEE analysis to describe growth pattern among lowland and hilltribe children.

The 10th, 50th, and 90th percentiles values of overall growth index were presented by children ethnicity in Figure 4.11. The overall growth index was increasing rapidly during 6 months of age, and more rapid increasing during next 2 months. In contrast, the overall growth index was decreasing during 8 to 10 months. Then, the overall growth index was rapid increasing again during 17 to 18 months of age. The curve was different from other growth indices that were presented previously. However, the curves were similar in both groups of children, and were not significant differences for all percentiles.

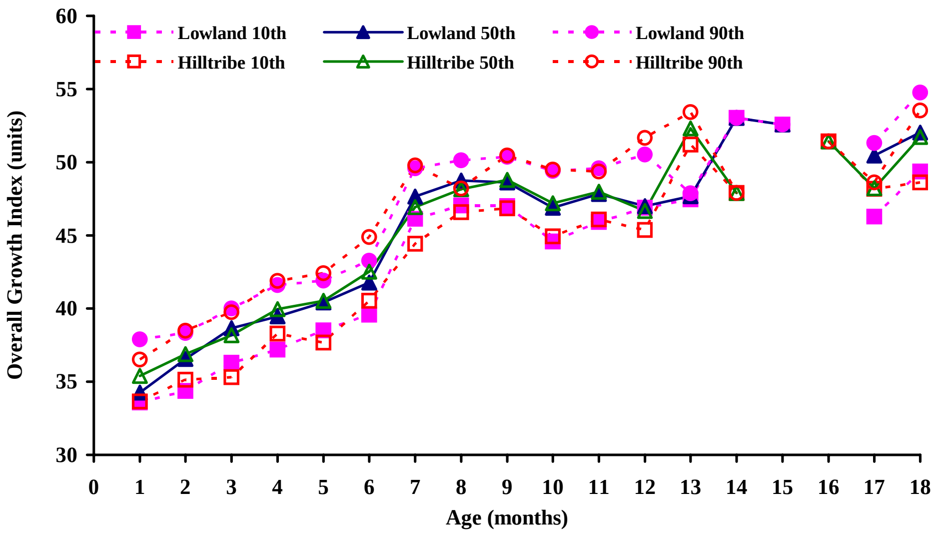

Figure 4.11 Overall Growth Index at 10th, 50th, and 90th Percentile for Lowland and Hilltribe Children

4.5. Within-subject Correlation Consideration

According to GEE model in equation (2.5), which could be described the relationship between a continuous outcome and one or more predictor variables at different time-points for each group of sample, as bellow;

$$Y_{pit} = \beta_0 + \sum_{p=1}^{2} \beta_{1p} X_{pit} + \beta_2 t + \sum_{k=1}^{K} \beta_{3pk} Z_{pikt} + \sum_{m=1}^{M} \beta_{4pm} G_{pim} + C_{pit} + \varepsilon_{pit} \qquad (2.5)$$

where Y_{pit} are observations for subject i at time t for each responses; weight for age, length for age, head circumference for age, and ponderal index. β_0 is the intercept, X_{pit} is the group variable, for subject i at time t, β_{1p} is the regression coefficient for group p, t is time. Suppose that the ethnicity defines as the independent categorical variable X_{pit} for subject i at time t, number of group (p) for X_{pit} is 2. Lowland children group is defined as p=1 and hilltribe is defined as p=2. Then β_2 is the regression coefficient for time, Z_{pikt} is the time-dependent covariate k for subject i in group p at time t, β_{3pk} is the regression coefficient for time-dependent covariate k, K is the number of time-dependent covariates, G_{pim} is the time-independent covariate m for subject i in group p, β_{4pm} is the regression coefficient for time-independent covariate m, M is the number of time-independent covariates, C_{pit} is the working correlation structure (Appendix B), and ε_{pit} is the error for subject i in group p at time t.

Because of the repeated observations within one subject were not independent of each other, a correlation must be made for these within-subject correlations. In GEE, this correlation was carried out by assuming a priori a certain working correlation structure for the repeated measurements of the outcome variable. There were many choices between various correlation structures. The results of analysis with different working correlation structures were different and lead to different conclusions. Therefore, it was important to realize which correlation structure was the most appropriate for the analysis. However, there was no directly method to determine the appropriate correlation structure. In this study, the results of analysis with different working correlation structure were compared, to find the appropriate correlation structure for this data. According to equation (2.5), WT, LT, HEAD, PONDERAL, and ALLGROWTH were defined as continuous outcome variables. A time variable was VISITMONTH. A group variable, time-dependent covariate and time-independent covariate were excluded. The GEE model would construct for each outcome variable, to compare the results with various correlation structures. Three structures of correlation were used to compare; (1) an exchangeable structure was that the correlations between subsequent measurements were assumed to be the same, (2) autoregressive structure which autoregressive was a term derived from times series analysis that assumes observations are related to their own past values through one, two, or a higher order autoregressive process. An autoregressive correlation structure indicates that two observations taken close in time or space within an individual tend to be more highly correlated than two observations taken far apart in time from the same individual, and (3) m-dependent structure or stationary structure was that the correlations t measurements apart were equal and the correlations $t+1$ measurements apart were assumed to be equal, and so on for $t=1$ to $t=m$ (Twisk, 2003).

Firstly, each outcome variable would put in GEE model with time variable by each correlation structure. The scale parameter was the dispersion parameter which was shown in an output program, and was related to the way in which the variance of the outcome variable was related to the expected values of the outcome variable. Then the standard deviation of the model was also known as (scale parameter)^{2} and the standard error of coefficient would be used for model comparison. Thus GEE model with the least standard deviation of the model and standard error of coefficient might indicate an appropriate correlation structure for that data. The results were show in Table 4.7 to 4.11.

For outcome variable “WT” in Table 4.7, GEE model that had the least standard deviation of the model was model with second order autoregressive correlation structure (1.132). However, the model with an exchangeable correlation structure gave the least standard error of coefficients of time variable VISITMONTH and intercept (0.003 and 0.042 respectively).

For outcome variable "LT" in Table 4.8, GEE model that had least standard deviation of the model was model with an exchangeable correlation structure (3.495), and also gave the least standard error of coefficients of time variable VISITMONTH and intercept (0.003 and 0.051 respectively).

For outcome variable "HEAD" in Table 4.9, GEE model that had the least standard deviation of the model was model with an exchangeable correlation structure (1.863), and also gave the least standard error of coefficients of time variable VISITMONTH and intercept (0.005 and 0.070 respectively).

For outcome variable "PONDERAL" in Table 4.10, GEE model that had the least standard deviation of the model was model with an exchangeable correlation structure (820.877), and also gave the least standard error of coefficients of time variable VISITMONTH and intercept (0.015 and 0.196 respectively).

Table 4.7 Models Comparison for Outcome Variable "WT" with Various Correlation Structures

WT	Correlation Structure of Model			
	Exch	AR(1)	AR(2)	Stat
Scale Parameter	1.779	1.742	1.064	1.807
Standard deviation the model	3.129	3.035	1.132	3.264
Coefficient				
VISITMONTH (time variable)	-0.093**	-0.186**	-0.219**	-0.112**
Intercept	1.438**	2.074**	1.811**	1.648**
Standard Error of Coefficient				
VISITMONTH (time variable)	0.003	0.073	0.066	0.074
Intercept	0.042	0.401	0.411	0403

Exch = An Exchangeable Correlation Structure, AR(1) = First Order Autoregressive Correlation Structure, AR(2) = Second Order Autoregressive Correlation Structure, and Stat = Stationary Correlation Structure, * Significant level at 0.01, ** Significant level at 0.05

Table 4.8 Models Comparison for Outcome Variable "LT" with Various Correlation Structures

LT	Correlation Structure of Model			
	Exch	AR(1)	AR(2)	Stat
Scale Parameter	1.870	3.787	4.189	3.789
Standard deviation the model	3.495	14.343	17.546	14.353
Coefficient				
VISITMONTH (time variable)	-0.056**	0.047	0.139	0.048
Intercept	0.637**	0.012	-0.529	-0.018
Standard Error of Coefficient				
VISITMONTH (time variable)	0.003	0.114	0.112	0.118
Intercept	0.051	0.623	0.747	0.635

Exch = An Exchangeable Correlation Structure, AR(1) = First Order Autoregressive Correlation Structure, AR(2) = Second Order Autoregressive Correlation Structure, and Stat = Stationary Correlation Structure, * Significant level at 0.01, ** Significant level at 0.05

Table 4.9 Models Comparison for Outcome Variable "HEAD" with Various Correlation Structures

HEAD	Correlation Structure of Model			
	Exch	AR(1)	AR(2)	Stat
Scale Parameter	1.365	3.610	1.421	3.602
Standard deviation the model	1.863	13.034	2.018	12.976
Coefficient				
VISITMONTH (time variable)	-0.095**	0.079	0.109	0.085
Intercept	1.471**	0.295	0.684	0.303
Standard Error of Coefficient				
VISITMONTH (time variable)	0.005	0.186	0.144	0.192
Intercept	0.070	0.876	0.737	0.899

Exch = An Exchangeable Correlation Structure, AR(1) = First Order Autoregressive Correlation Structure, AR(2) = Second Order Autoregressive Correlation Structure, and Stat = Stationary Correlation Structure, * Significant level at 0.01, ** Significant level at 0.05

Table 4.10 Models Comparison for Outcome Variable "PONDERAL" with Various Correlation Structures

PONDERAL	Correlation Structure of Model			
	Exch	AR(1)	AR(2)	Stat
Scale Parameter	28.649	111.566	172.95	111.555
Standard Deviation of the Model	820.877	12,446.995	29,920.316	12,444.674
Coefficient				
VISITMONTH (time variable)	-0.526**	-1.613**	-1.921*	-1.595**
Intercept	30.517**	37.047**	39.246**	36.999**
Standard Error of Coefficient				
VISITMONTH (time variable)	0.015	0.632	1.041	0.636
Intercept	0.196	3.353	5.861	3.367

Exch = An Exchangeable Correlation Structure, AR(1) = First Order Autoregressive Correlation Structure, AR(2) = Second Order Autoregressive Correlation Structure, and Stat = Stationary Correlation Structure, * Significant level at 0.01, ** Significant level at 0.05

For outcome variable "ALLGROWTH" in Table 4.11, GEE model that had the least standard deviation of the model was model with second autoregressive correlation structure (5.222). However, GEE model with an exchangeable correlation structure gave the least standard error of coefficients of time variable VISITMONTH and intercept (0.013 and 0.151 respectively).

Table 4.11 Models Comparison for Outcome Variable "ALLGROWTH" with Various Correlation Structures

ALLGROWTH	Correlation Structure of Model			
	Exch	AR(1)	AR(2)	Stat
Scale Parameter	7.096	3.775	2.285	3.776
Standard deviation the model	50.362	14.252	5.222	14.255
Coefficient				
VISITMONTH (time variable)	0.903**	1.978**	1.976**	1.977**
Intercept	36.477**	30.768**	31.394**	30.808**
Standard Error of Coefficient				
VISITMONTH (time variable)	0.013	0.194	0.169	0.198
Intercept	0.151	0.904	0.855	0.919

Exch = An Exchangeable Correlation Structure, AR(1) = First Order Autoregressive Correlation Structure, AR(2) = Second Order Autoregressive Correlation Structure, and Stat = Stationary Correlation Structure, * Significant level at 0.01, ** Significant level at 0.05

In conclusion, GEE model of three outcome variables; LT, HEAD, and PONDERAL with an exchangeable correlation structure were the least standard deviation of model and standard error of coefficient (Table 4.8, 4.9. and 4.10). For another two outcome variables; WT and ALLGROWTH with 2^{nd} order autoregressive correlation structure were gave the least standard deviation of model (Table 4.7 and 4.11). Whereas, the GEE model with an exchangeable correlation structure was gave the least standard error of coefficient. Thus in this analysis, GEE model with an *exchangeable correlation structure* might be an appropriate correlation structure.

4.6. Univariate GEE Analysis

In the univariate GEE analysis, the time-dependent covariate would not included in the model because of data collections were unavailable. Thus the general form of univariate GEE simple model would describe the relationship between a continuous outcome and each predictor variable at different time-points by;

$$Y_{it} = \beta_0 + \beta_2 t + \beta_4 G_i + C_{it} + \varepsilon_{it} \quad (4.1)$$

where Y_{it} were observations for subject i at time t for each responses; WT, LT, HEAD, PONDERAL, and ALLGROWTH. β_0 was the intercept, t was time, β_2 was the regression coefficient for time, G_i was the time-independent covariate for subject i in group p, β_4 was the regression coefficient for time-independent covariate, C_{it} was the working correlation structure, and ε_{it} was the error for subject i at time t.

In GEE model, group variable, time variable and one time-independent covariate were included for each outcome variable. The time variable defined as visit month for immunization schedule after birth and the group variable were separated by maternal ethnicity. The model selection was used *enter method*. Then, each time-independent covariate of interest was tested in a univariate GEE model. Individual time-independent covariates with p<0.10 were candidates for multivariate modeling in next step. Time-independent covariate PRETERM was dummy variable that conducted from GESTATION. If both covariates were significant associated with outcome variable, then GESTATION would include in multivariate GEE analysis only. As well, LOWBW, MULTIPREG, and PARITY were dummy variables that conducted from BWKG, PREGORDER, and CHILDORDER respectively. If both covariates in each couple were significant associated with outcome variable, then only the continuous variable would include in multivariate analysis. In case of time-independent covariates, DELIVER1 and DELIVER2 were dummy variables of delivery method. If either was significant associated with outcome variable, then both would be included in multivariate GEE analysis. In addition, AGEMOM1, AGEMOM2, and AGEMOM3 were dummy variables of maternal age, then all would be included in multivariate analysis if either was significant associated with outcome variable. However, AGEMOM are continuous variable of maternal age. If both AGEMOM and age group categorized variable were significant associated with outcome variable, only AGEMOM would be included in multivariate analysis.

4.6.1. Weight for Age

The results of a GEE analysis was applied to investigate the relationship between the outcome variable "WT", and time-independent covariates. Time was added to the model as a continuous variable, visit month. The results of the univariate GEE model to predict outcome variable "WT" were shown in Table 4.12 by each time-independent covariate. For each of the time-independent covariates, intercept, the regression coefficient for time variable (VISITMONTH), the regression coefficient (beta), and the corresponding p-value of regression coefficient were given.

From equation 4.1, the univariate GEE model with an exchangeable correlation structure could model in each time-independent covariate among lowland and hilltribe children. In lowland children, there were 10 time-independent covariates that had $p<0.10$. These covariates were significant associated with outcome variable "WT". Then the univariate GEE model could be 10 models as follows;

Lowland children;

*WT = -1.587 -0.081*VISITMONTH +0.074*GESTATION*

*WT = -2.109 -0.081*VISITMONTH +1.103*BWKG*

*WT = 1.326 -0.080*VISITMONTH -0.656*LOWBW*

*WT = -2.995 -0.080*VISITMONTH +0.084*BLT*

*WT = -1.649 -0.080*VISITMONTH +0.091*BHEAD*

*WT = 1.596 -0.080*VISITMONTH -0.309*CHILDNO*

*WT = 1.259 -0.081*VISITMONTH +0.208*DELIVER1*

*WT = 1.259 -0.081*VISITMONTH -0.489*DELIVER2*

*WT = 1.199 -0.081*VISITMONTH +0.004*AGEMOM*

*WT = 1.049 -0.082*VISITMONTH +0.027*ANCTIME*

The interpretations of the magnitude of these models were following;

For overall view, weight for age z-score of lowland children was decreased 0.08 in every month of next visit.

In case of gestational age in lowland children was increased one week, then weight for age z-score would also increase 0.074.

Lowland children who had birth weight more than others one kg, then weight for age z-score would also increase 1.103.

Low birth weight lowland children would have weight for age z-score less than others 0.656.

Lowland children who had birth length more than others one cm, then weight for age z-score would also increase 0.084.

In addition lowland children who had birth head circumference more than others one cm, then weight for age z-score would also increase 0.091.

Lowland children who were twin birth would have weight for age z-score less than singleton birth 0.309.

Weight for age z-score of lowland children who were born by cesarean section would more than lowland children who were born normally 0.208. But weight for age z-score of lowland children who were born by other delivery methods except normally delivery and cesarean section would lower than lowland children who were born normally 0.489 kg.

Lowland mother who older than others one year, then weight for age z-score of children would more than others 0.004.

Finally, lowland mother who was attended ANC visits more than others one time, then weight for age z-score of children would increase more than others 0.027.

For hilltribe children, there were 5 time-independent covariates that had $p<0.10$. Then the univariate GEE model could be 5 models as following;

Hilltribe children;

*WT = 1.755 -0.124*VISITMONTH -0.588*PRETERM*

*WT = -1.642 -0.123*VISITMONTH +1.080*BWKG*

*WT = 1.777 -0.123*VISITMONTH -1.139*LOWBW*

*WT = -1.731 -0.124*VISITMONTH +0.068*BLT*

*WT = 1.910 -0.123*VISITMONTH -0.079*PREGORDER*

The interpretations of the magnitude of these models were as following;

For overall view, weight for age z-score of hilltribe children was decreased 0.12 in every month of next visit.

Hilltribe children with preterm delivery would have weight for age z-score less than others 0.588.

Hilltribe children who had birth weight more than others one kg, then weight for age z-score would also increase 1.080.

Low birth weight hilltribe children would have weight for age z-score less than others 1.139.

In contrast, hilltribe children who had birth length more than others one cm, then weight for age z-score would also increase 0.068.

Finally, hilltribe child who was not the first child, then weight for age z-score would less than children in previous order 0.079.

According to the univariate GEE results of WT in Table 4.7, the time-independent covariates; GESTATION, BWKG, LOWBW, BLT, BHEAD, CHILDNO, DELIVER1, DELIVER2, AGEMOM, and ANCTIME, were significant associated with outcome variable WT in lowland children. In addition, the time-independent covariates; PRETERM, BWKG, LOWBW, BLT, and PREGORDER, were significant associated with outcome variable WT in hilltribe children. Then, with significant level 0.10, the time-independent covariates that were significant associated with WT among lowland or hilltribe children; GESTATION, PRETERM, BWKG, BLT, BHEAD, PREGORDER, CHILDNO, DELIVER1, DELIVER2, AGEMOM, and ANCTIME, were candidate for multivariate modeling of WT.

Table 4.12 Results from the Univariate GEE Analysis of Weight for Age among Lowland and Hilltribe Children

Variables	Lowland Children				Hilltribe Children			
	Intercept	VISITMONTH	beta	p	Intercept	VISITMONTH	beta	p
FEMALE	1.295	-0.080	-0.015	0.846	1.640	-0.123	0.134	0.288
GESTATION	-1.587	-0.081	0.074	0.001 *	-0.317	-0.124	0.052	0.161
PRETERM	1.293	-0.081	-0.219	0.170	1.755	-0.124	-0.588	0.009 *
BWKG	-2.109	-0.081	1.103	<0.001 *	-1.642	-0.123	1.080	<0.001 *
LOWBW	1.326	-0.080	-0.656	<0.001 *	1.777	-0.123	-1.139	<0.001 *
BLT	-2.995	-0.080	0.084	<0.001 *	-1.731	-0.124	0.068	0.003 *
BPONDERAL	1.189	-0.080	0.004	0.526	1.509	-0.124	0.009	0.250
BHEAD	-1.649	-0.080	0.091	<0.001 *	-0.030	-0.124	0.054	0.114
PREGORDER	1.271	-0.080	0.006	0.889	1.910	-0.123	-0.079	0.034 *
MULTIPREG	1.313	-0.080	-0.059	0.453	1.739	-0.124	-0.032	0.821
CHILDORDER	1.271	-0.080	0.006	0.921	1.854	-0.122	-0.045	0.360
PARITY	1.306	-0.080	-0.059	0.469	1.688	-0.122	0.108	0.462
BIRTHSPACE	1.301	-0.089	0.004	0.793	1.980	-0.135	-0.030	0.258
CHILDNO	1.596	-0.080	-0.309	0.015 *	1.824	-0.123	-0.116	0.800
DELIVER1	1.259	-0.081	0.208	0.032 *	1.693	-0.122	0.138	0.511
DELIVER2	1.259	-0.081	-0.489	0.006 *	1.693	-0.122	-0.248	0.418
AGEMOM	1.199	-0.081	0.004	0.004 *	1.916	-0.123	-0.009	0.354
AGEMOM1	1.227	-0.081	0.074	0.458	1.562	-0.122	0.244	0.113
AGEMOM2	1.227	-0.081	0.142	0.231	1.562	-0.122	-0.003	0.988
AGEMOM3	1.227	-0.081	0.165	0.564	1.562	-0.122	-0.314	0.413
HIVMOMPOS	1.298	-0.080	-0.249	0.213	1.729	-0.123	-0.434	0.145
HCT	1.334	-0.080	-0.001	0.566	1.723	-0.123	-0.0004	0.882
ANCTIME	1.049	-0.082	0.027	0.029 *	1.639	-0.126	0.017	0.436

* Significant level at 0.10

4.6.2. Length for Age

The results of the univariate GEE model to predict outcome variable “LT” were shown in Table 4.13 by each time-independent covariate. For each of the time-independent covariate, intercept, the regression coefficient for time variable (VISITMONTH), the regression coefficient (beta), and the corresponding p-value of regression coefficient were given.

In lowland children, there were 7 time-independent covariates that had $p<0.10$. These covariates were significant associated with outcome variable “LT”. Then the univariate GEE models were interpreted as following;

For overall view, height for age z-score in lowland children was decreased 0.05 in every month of next visit.

Lowland children who were born at gestational age more than others one week, then length for age z-score would also increase 0.102.

Lowland children who had birth weight more than others one kg, then length for age z-score would also increase 0.801.

Low birth weight lowland children would have length for age z-score less than others 0.684.

Lowland children who had birth length more than others one cm, then length for age z-score would also more than others 0.073.

Lowland children who had birth head circumference more than others one cm, then length for age z-score would also increase more than others 0.063.

Length for age z-core of lowland children who were born by other delivery methods except normally delivery and cesarean section would be lower than who were born normally 0.974. Whereas Length of lowland children who were born by cesarean section did not differ from who were born normally.

Lastly, the lowland children who were born to mother visited ANC more than others one time, then length for age z-score would increase 0.011.

For hilltribe children, there were 11 time-independent covariates that had $p<0.10$. Then the univariate GEE models were interpreted as following;

For overall view, height for age z-score of hilltribe children was decreased 0.07 in every month of next visit.

Hilltribe children who had birth weight more than others one kg, then length for age z-score would also increase more than others 0.889.

Low birth weight hilltribe children would have length for age z-score less than others 1.007.

Hilltribe children who had birth head circumference more than others one cm, then length for age z-score would also increase 0.115.

In case of hilltribe mother who was pregnant more than others one time, the child would have length for age z-score less than others 0.227. Also, a hilltribe child who was born from multiple pregnancy mother would had length for age z-score less than a child who was born from single pregnancy mother 0.397.

A hilltribe child who was not the first order would have length for age z-score less than the previous order 0.222. Likewise, the parious hilltribe child would have length for age z-score less than the nulliparious child 0.409. In contrast, lowland child who was not single child and had birth spacing one year from previous order, the length for age z-score would be decrease 0.056.

The hilltribe mother who was older than others one year then length for age z-score of children would lower than others 0.054.

Finally, hilltribe children who was born to mother aged 30 to 39 and ≥ 40 year-old would had length for age z-score significant less than who was born to mother aged under 20 year-old, 0.847 and 1.409 cm respectively.

According to the univariate GEE results of LT, the time-independent covariates; GESTATION, BWKG, LOWBW, BLT, BHEAD, DELIVER2, and ANCTIME, were significant associated with outcome variable LT in lowland children. In addition, the time-independent covariates; BWKG, LOWBW, BHEAD, PREGORDER, MULTIPREG, CHILDORDER, PARITY, BIRTHSPACE, AGEMOM, AGEMOM2, and AGEMOM3, were significant associated with outcome variable LT in hilltribe children. In conclusion, with significant level 0.10, the time-independent covariates that were significant associated with LT among lowland or hilltribe children; GESTATION, BWKG, BLT, BHEAD, PREGORDER, CHILDORDER, BIRTHSPACE, DELIVER1, DELIVER2, AGEMOM, and ANCTIME, were candidate for multivariate modeling of LT.

Table 4.13 Results from the Univariate GEE Analysis of Length for Age among Lowland and Hilltribe Children

Variables	Lowland Children				Hilltribe Children			
	Intercept	VISITMONTH	Beta	p	Intercept	VISITMONTH	Beta	p
FEMALE	0.607	-0.050	-0.054	0.533	0.685	-0.071	0.099	0.557
GESTATION	-3.389	-0.049	0.102	<0.001 *	-1.773	-0.070	0.063	0.173
PRETERM	0.587	-0.049	-0.273	0.106	0.690	-0.070	-0.443	0.242
BWKG	-1.872	-0.051	0.801	<0.001 *	-2.063	-0.072	0.889	<0.001 *
LOWBW	0.627	-0.050	-0.684	<0.001 *	0.764	-0.072	-1.007	<0.001 *
BLT	-3.121	-0.050	0.073	<0.001 *	-0.571	-0.072	0.026	0.418
BPONDERAL	0.553	-0.050	0.001	0.859	0.324	-0.072	0.017	0.105
BHEAD	-1.474	-0.050	0.063	0.002 *	-3.021	-0.071	0.115	0.008 *
PREGORDER	0.672	-0.049	-0.062	0.155	1.260	-0.070	-0.227	<0.001 *
MULTIPREG	0.608	-0.049	-0.085	0.328	0.976	-0.070	-0.397	0.040 *
CHILDORDER	0.693	-0.048	-0.073	0.306	1.286	-0.075	-0.222	<0.001 *
PARITY	0.625	-0.048	-0.101	0.280	1.043	-0.076	-0.409	0.036 *
BIRTHSPACE	0.581	-0.048	-0.007	0.686	0.975	-0.081	-0.056	0.065 *
CHILDNO	0.529	-0.050	0.053	0.837	1.076	-0.071	-0.336	0.369
DELIVER1	0.599	-0.050	-0.054	0.635	0.725	-0.071	0.210	0.373
DELIVER2	0.599	-0.050	-0.974	0.023 *	0.725	-0.071	-0.349	0.292
AGEMOM	0.470	-0.050	0.004	0.552	2.070	-0.071	-0.054	<0.001 *
AGEMOM1	0.551	-0.051	0.036	0.746	1.164	-0.071	-0.383	0.171
AGEMOM2	0.551	-0.051	0.129	0.340	1.164	-0.071	-0.847	0.004 *
AGEMOM3	0.551	-0.051	0.347	0.369	1.164	-0.071	-1.409	0.002 *
HIVMOMPOS	0.581	-0.050	-0.046	0.751	0.733	-0.072	0.546	0.399
HCT	0.555	-0.050	0.001	0.767	0.803	-0.071	-0.002	0.637
ANCTIME	0.279	-0.049	0.031	0.011 *	0.538	-0.075	0.029	0.312

* Significant level at 0.10

4.6.3. Head Circumference for Age

The results of the univariate GEE model to predict outcome variable “HEAD” were shown in Table 4.14 by each time-independent covariate. For each of the independent variables, intercept, the regression coefficient for time variable (VISITMONTH), the regression coefficient (beta), and the corresponding p-value of regression coefficient were given.

In lowland children, there were 11 time-independent covariates that had $p<0.10$. These covariates were significant associated with outcome variable “HEAD”. Then the univariate GEE models were interpreted as following;

For overall view, head circumference for age of lowland children z-score was decreased 0.09 in every month of next visit.

Female-lowland children would have head circumference for age z-score less than male-lowland children 0.336.

Lowland children who were born at gestational age more than others one week, then head circumference for age z-score would also increase 0.112.

Lowland children who had birth weight more than others one kg, then head circumference for age z-score would also increase 0.765.

Low birth weight lowland children would have head circumference for age z-score less than others 1.096.

Lowland children who had birth ponderal index more than others one kg/m^3, head circumference for age z-score would also increase 0.016.

In addition, lowland children who had birth head circumference more than others one cm, head circumference for age z-score would also increase 0.128.

In multiple pregnant women, if mother was pregnant more than others one time, head circumference for age z-score would less than others 0.103. Similarly, a lowland child who was born from multiple pregnancy mother would had head circumference for age z-score less than a child who was born from single pregnancy mother 0.285.

The parious lowland child would have head circumference for age z-score less than the nulliparious child 0.340.

Among the parious lowland child who was had birth spacing from previously increase one year, head circumference for age z-score would decrease 0.071.

Lastly, head circumference for age z-score of lowland children who were born by cesarean section would be more than lowland children who were born normally 0.528. Whereas head circumference for age z-score of lowland children who were born by other delivery method except cesarean section and normally delivery did not differ from who were born normally.

For hilltribe children, there were 4 time-independent covariates that had p<0.10. Then the univariate GEE models were interpreted as following;

For overall view, head circumference for age of hilltribe children z-score was decreased 0.10 in every month of next visit.

Hilltribe children who had birth weight more than others one kg, then head circumference for age z-score would also increase 1.071.

Hilltribe children who had birth length more than others one cm, then head circumference for age z-score would also increase 0.131.

Hilltribe children who had birth head circumference more than others one cm, then head circumference for age z-score would also increase 0.337.

Finally, hilltribe children who was born to mother aged 30 to 39 would had head circumference for age z-score significant more than who was born to mother aged under 20 year-old 0.714.

According to the univariate GEE results of HEAD, the independent variables; FEMALE, GESTATION, BWKG, LOWBW, BPONDERAL, BHEAD, PREGORDER, MULTIPREG, PARITY, BIRTHSPACE, and DELIVER1, were significant associated with outcome variable HEAD in lowland children. In addition, the independent variables; BWKG, BLT, BHEAD, and AGEMOM2, were significant associated with outcome variable HEAD in hilltribe children. Then, with significant level 0.10, the independent variables that were significant associated with HEAD among lowland or hilltribe children; FEMALE, GESTATION, BWKG, BLT, BPONDERAL, BHEAD, PREGORDER, PARITY, BIRTHSPACE, DELIVER1, DELIVER2, AGEMOM1, AGEMOM2, and AGEMOM3, were candidates for multivariate modeling of HEAD.

Table 4.14 Results from the Univariate GEE Analysis of Head Circumference for Age among Lowland and Hilltribe Children

Variables	Lowland Children					Hilltribe Children				
	Intercept	VISITMONTH	Beta	p		Intercept	VISITMONTH	Beta	p	
FEMALE	1.558	-0.090	-0.336	0.016	*	1.705	-0.097	-0.312	0.207	
GESTATION	-2.956	-0.091	0.112	0.018	*	-0.664	-0.098	0.057	0.414	
PRETERM	1.425	-0.091	-0.545	0.241		1.566	-0.098	-0.136	0.798	
BWKG	-0.956	-0.091	0.765	<0.001	*	-1.774	-0.097	1.071	0.001	*
LOWBW	1.456	-0.091	-1.096	0.013	*	1.579	-0.098	-0.372	0.467	
BLT	-0.268	-0.090	0.033	0.309		-5.199	-0.099	0.131	0.006	*
BPONDERAL	1.018	-0.090	0.016	0.001	*	2.052	-0.100	-0.022	0.586	
BHEAD	-2.735	-0.091	0.128	0.006	*	-9.390	-0.097	0.337	<0.001	*
PREGORDER	1.578	-0.090	-0.103	0.096	*	1.605	-0.098	-0.018	0.837	
MULTIPREG	1.539	-0.090	-0.285	0.041	*	1.467	-0.098	0.143	0.585	
CHILDORDER	1.660	-0.090	-0.179	0.148		1.494	-0.102	0.037	0.749	
PARITY	1.536	-0.090	-0.340	0.022	*	1.534	-0.102	0.071	0.788	
BIRTHSPACE	1.757	-0.100	-0.071	0.061	*	1.345	-0.079	0.019	0.750	
CHILDNO	1.299	-0.090	0.085	0.865		1.991	-0.097	-0.433	0.262	
DELIVER1	1.295	-0.091	0.528	0.001	*	1.508	-0.098	0.295	0.352	
DELIVER2	1.295	-0.091	-0.228	0.595		1.508	-0.098	0.644	0.441	
AGEMOM	1.875	-0.090	-0.019	0.184		1.120	-0.096	0.017	0.478	
AGEMOM1	1.395	-0.090	0.050	0.775		1.198	-0.097	0.415	0.173	
AGEMOM2	1.395	-0.090	0.030	0.899		1.198	-0.097	0.714	0.052	*
AGEMOM3	1.395	-0.090	-1.393	0.132		1.198	-0.097	-0.513	0.382	
HIVMOMPOS	1.363	-0.090	0.358	0.231		1.623	-0.102	-0.025	0.956	
HCT	1.178	-0.090	0.004	0.111		1.781	-0.097	-0.005	0.404	
ANCTIME	1.345	-0.092	0.007	0.754		1.659	-0.105	0.005	0.899	

* Significant level at 0.10

4.6.4. Ponderal Index

The results of the univariate GEE model to predict outcome variable "PONDERAL" were shown in Table 4.15 by each independent variable. For each of the independent variables, intercept, the regression coefficient for time variable (VISITMONTH), the regression coefficient (beta), and the corresponding p-value of regression coefficient were given.

In lowland children, there were 8 time-independent covariates that had $p<0.10$. These covariates were significant associated with outcome variable "PONDERAL". Then the the univariate GEE models were interpreted as following;

For overall view, ponderal index of lowland children z-score was decreased 0.51 in every month of next visit.

Female-lowland children would have ponderal index less than male-lowland children 0.575 kg/m^3.

Lowland children who were born at gestational age more than others one week would also decrease ponderal index 0.154 kg/m^3.

The lowland mother who was pregnant more than others one time, then the children would be increased ponderal index more than 0.349 kg/m^3.

The children who were born to multiple pregnant lowland mother would be had ponderal index more than who were born to single pregnant mother 0.610 kg/m^3.

A lowland child who was not the first order would have ponderal index more than the previous order 0.44 kg/m^3. Likewise, the parious lowland child would have length more than the nulliparious child 0.532 kg/m^3.

A twin lowland child would have ponderal index less than a single child 0.915 kg/m^3.

Ponderal index of lowland children who were born by other delivery methods except normally delivery and cesarean section would be more than who were born normally 3.565 kg/m^3. Whereas ponderal index lowland children who were born by cesarean section did not differ from who were delivered normally.

For hilltribe children, there were 10 time-independent covariates that had $p<0.10$. Then the univariate GEE models were interpreted as following;

For overall view, ponderal index of hilltribe children z-score was decreased 0.57 in every month of next visit.

A hilltribe child, who had ponderal index at birth more than others one kg/m^3, would have ponderal index less than others 0.045 kg/m^3.

Hilltribe children who had birth head circumference more than others one cm would decrease ponderal index 0.280 kg/m^3.

The hilltribe mother who was pregnant more than others one time, then the child would be increased ponderal index more than 0.485 kg/m^3.

Hilltribe children who were born to multiple children family would have ponderal index more than hilltribe mother who were born to single chidren 1.114 kg/m^3.

A hilltribe child who was not the first order would have ponderal index more than the previous order 0.620 kg/m^3. Likewise, the parious hilltribe child would have length more than the nulliparious child 1.633 kg/m^3.

The hilltribe mother who was older than others one year then the children would have ponderal index more than others 0.149 kg/m^3.

Hilltribe children who were born to mother aged 30 to 39 and ≥ 40 year-old would have ponderal index more than hilltribe children who were born to mother aged more than 20 year-old, 1.923, and 4.944 kg/m^3 respectively. Whereas ponderal index of hilltribe children who were born to mother aged less than 20 and 20 to 29 year-old was not different.

Finally, hilltribe child who was born to HIV infected mother would have ponderal index less than who was born to HIV uninfected mother 3.726 kg/m^3.

Table 4.15 Results from the Univariate GEE Analysis of Ponderal Index among Lowland and Hilltribe Children

Variables	Lowland Children				Hilltribe Children			
	Intercept	VISITMONTH	Beta	p	Intercept	VISITMONTH	Beta	p
FEMALE	30.454	-0.509	-0.575	0.050 *	31.369	-0.566	-0.335	0.525
GESTATION	36.224	-0.515	-0.154	0.075 *	37.200	-0.574	-0.148	0.366
PRETERM	30.216	-0.515	0.139	0.802	31.369	-0.573	0.906	0.630
BWKG	28.688	-0.510	0.483	0.213	31.415	-0.565	-0.058	0.916
LOWBW	30.165	-0.509	0.024	0.968	31.242	-0.565	-0.360	0.633
BLT	28.638	-0.510	0.030	0.485	26.956	-0.568	0.083	0.276
BPONDERAL	30.092	-0.507	0.002	0.896	32.318	-0.567	-0.045	0.074 *
BHEAD	28.973	-0.511	0.037	0.464	40.411	-0.568	-0.280	0.011 *
PREGORDER	29.615	-0.514	0.349	0.039 *	30.146	-0.573	0.485	0.002 *
MULTIPREG	29.912	-0.515	0.610	0.040 *	30.571	-0.572	1.114	0.065 *
CHILDORDER	29.378	-0.509	0.445	0.057 *	29.779	-0.552	0.620	0.004 *
PARITY	29.827	-0.509	0.532	0.081 *	30.166	-0.550	1.633	0.008 *
BIRTHSPACE	30.697	-0.559	0.028	0.596	31.110	-0.574	0.134	0.262
CHILDNO	31.104	-0.509	-0.915	0.094 *	31.190	-0.567	0.024	0.981
DELIVER1	30.043	-0.511	0.490	0.139	31.368	-0.569	-0.966	0.141
DELIVER2	30.043	-0.511	3.565	0.095 *	31.368	-0.569	0.124	0.908
AGEMOM	30.014	-0.512	0.007	0.762	27.479	-0.566	0.149	0.006 *
AGEMOM1	29.990	-0.507	0.152	0.682	30.042	-0.565	1.070	0.194
AGEMOM2	29.990	-0.507	0.291	0.512	30.042	-0.565	1.923	0.030 *
AGEMOM3	29.990	-0.507	-0.160	0.863	30.042	-0.565	4.944	0.039 *
HIVMOMPOS	30.227	-0.510	-0.743	0.174	31.284	-0.569	-3.726	<0.001 *
HCT	30.406	-0.511	-0.005	0.430	31.064	-0.566	0.003	0.745
ANCTIME	30.606	-0.517	-0.038	0.400	32.139	-0.562	-0.110	0.237

* Significant level at 0.10

According to the univariate GEE results of PONDERAL, the independent variables; FEMALE, GESTATION, PREGORDER, MULTIPREG, CHILDORDER, PARITY, CHILDNO, and DELIVER2, were significant associated with outcome variable PONDERAL in lowland children. In addition, the independent variables; BPONDERAL, BHEAD, PREGORDER, MULTIPREG, CHILDORDER, PARITY, AGEMOM, AGEMOM2, AGEMOM3, and HIVMOMPOS, were significant associated with outcome variable PONDERAL in hilltribe children. Then, with significant level 0.10, the independent variables that were significant associated with PONDERAL among lowland or hilltribe children; FEMALE, GESTATION, BPONDERRAL, BHEAD, PREGORDER, CHILDORDER, CHILDNO, DELIVER1, DELIVER2, AGEMOM, and HIVMOMPOS, were candidates for multivariate modeling of PONDERAL.

4.6.5. Overall Growth Index

The results of the univariate GEE model to predict outcome variable "ALLGROWTH" were shown in Table 4.16 by each independent variable. For each of the independent variables, intercept, the regression coefficient for time variable (VISITMONTH), the regression coefficient (beta), and the corresponding p-value of regression coefficient were given.

In lowland children, there were 8 time-independent covariates that had $p<0.10$. These covariates were significant associated with outcome variable "ALLGROWTH". Then the univariate GEE models were interpreted as following;

For overall view, overall growth index of lowland children z-score was decreased 0.89 in every month of next visit.

Female-lowland children would have overall growth index less than male-lowland children 1.183.

Lowland children who were born at gestational age more than others one week would also increase overall growth index 0.236.

Lowland children who had birth weight more than others one kg would also increase overall growth index 1.748.

Low birth weight lowland children would have overall growth index less than others 1.615.

Lowland children who had ponderal index at birth more than others one kg/m^3 would also increase overall growth index 0.023.

Lowland children who had birth head circumference more than others one cm would also increase overall growth index 0.221.

Overall growth index of lowland children who were born by cesarean section would be more than lowland children who were born normally 0.592. In contrast, lowland children who were born by other delivery methods except normally delivery and cesarean section would have overall growth index lower than lowland children who were born normally 1.459.

For hilltribe children, there were 7 time-independent covariates that had $p<0.10$. Then the univariate GEE model could interpret as following;

For overall view, overall growth index of hilltribe children z-score was decreased 0.85 in every month of next visit.

Female-hilltribe children would have overall growth index less than male-hilltribe children 1.380.

Hilltribe children who had birth weight more than others one kg would also increase overall growth index 2.081.

Low birth weight hilltribe children would have overall growth index less than others 1.524.

Hilltribe children who had birth length more than others one cm would also increase overall growth index 0.230.

Hilltribe children who had birth head circumference more than others one cm would also increase overall growth index 0.362.

The hilltribe mother who was pregnant more than others one time, then the children would be decreased overall growth index 0.147.

Lastly, twin hilltribe children would have overall growth index less than the singleton children 1.519.

Table 4.16 Results from the Univariate GEE Analysis of Overall Growth Index among Lowland and Hilltribe Children

Variables	Lowland Children				Hilltribe Children			
	Intercept	VISITMONTH	Beta	p	Intercept	VISITMONTH	Beta	p
FEMALE	37.132	0.894	-1.183	<0.001 *	37.509	0.854	-1.380	<0.001 *
GESTATION	27.331	0.890	0.236	0.024 *	31.061	0.854	0.148	0.106
PRETERM	36.537	0.891	-0.228	0.853	36.836	0.852	-0.069	0.923
BWKG	31.170	0.891	1.748	<0.001 *	30.324	0.857	2.081	<0.001 *
LOWBW	36.634	0.891	-1.615	0.003 *	36.908	0.852	-1.524	0.014 *
BLT	30.513	0.892	0.119	0.109	25.025	0.852	0.230	0.001 *
BPONDERAL	35.990	0.893	0.023	0.028 *	36.450	0.849	0.018	0.813
BHEAD	29.440	0.891	0.221	0.002 *	25.085	0.855	0.362	0.002 *
PREGORDER	36.649	0.892	-0.060	0.615	37.192	0.853	-0.147	0.073 *
MULTIPREG	36.697	0.893	-0.310	0.244	37.155	0.853	-0.473	0.202
CHILDORDER	36.885	0.892	-0.236	0.352	36.927	0.853	-0.062	0.617
PARITY	36.700	0.891	-0.398	0.148	36.948	0.853	-0.282	0.494
BIRTHSPACE	36.789	0.885	-0.048	0.398	36.772	0.845	0.007	0.921
CHILDNO	36.729	0.893	-0.194	0.663	38.382	0.854	-1.519	0.019 *
DELIVER1	36.450	0.892	0.592	0.034 *	36.842	0.852	0.030	0.951
DELIVER2	36.450	0.892	-1.459	0.048 *	36.842	0.852	0.141	0.925
AGEMOM	36.361	0.893	0.007	0.784	36.702	0.854	0.004	0.896
AGEMOM1	36.350	0.890	0.239	0.481	36.467	0.850	0.485	0.271
AGEMOM2	36.350	0.890	0.466	0.289	36.467	0.850	0.547	0.249
AGEMOM3	36.350	0.890	-0.861	0.500	36.467	0.850	-0.685	0.428
HIVMOMPOS	36.542	0.893	-0.118	0.818	36.885	0.848	-0.448	0.802
HCT	36.254	0.893	0.006	0.225	37.103	0.853	-0.006	0.459
ANCTIME	36.244	0.889	0.034	0.396	36.740	0.853	0.016	0.760

* Significant level at 0.10

According to the univariate GEE results of ALLGROWTH, the independent variables; FEMALE, GESTATION, BWKG, LOWBW, BPONDERAL, BHEAD, DELIVER1, and DELIVER2, were significant associated with outcome variable ALLGROWTH in lowland children. In addition, the independent variables; FEMALE, BWKG, LOWBW, BLT, BHEAD, PREGORDER, and CHILDNO, were significant associated with outcome variable ALLGROWTH in hilltribe children. Then, with significant level 0.10, the independent variables that were significant associated with ALLGROWTH among lowland or hilltribe children; FEMALE, GESTATION, BWKG, BLT, BPONDERAL, BHEAD, PREGORDER, CHILDNO, DELIVER1, and DELIVER2, were candidates for multivariate modeling of ALLGROWTH.

4.7. Multivariate GEE Analysis

Twisk (2003: 55-101) explained that from GEE model that, the number of subjects, the Standard Deviation of the Model, and the number of iterations needed to obtain the estimates of the regression coefficients. The Scale Parameter in GEE output is also known as the dispersion parameter, and is related to the way in which the standard deviation of the outcome variable is related to the expected values of the outcome variable. In multivariate GEE model comparison, model that was determined *the least standard deviation* might be an appropriate model for association between outcome variable and independent variables.

In this part, multivariate GEE models can show the association between one outcome variable and one or more time-independent covariates which significantly associated with each outcome variable in the univariate GEE model at significant level 0.10. The multivariate GEE models were compared the results from three regression methods; enter, backward, and forward. The time-variable and group variable always considered in all of model, only time-independent covariate would considered for including or excluding. Model fitting was tested by using *Wald Chi-square statistic and the corresponding p-value.* In addition, for each time-independent covariate, the coefficient and corresponding p-value that is based on the Wald statistic were used to consider the significant association with outcome variables.

For *enter method,* all independent variables that were significant associated with each outcome variable were entered in model. Then all of time-independent variables that were not associated with each outcome variable were excluded from final model. For *backward method,* all time-independent covariates that were significant associated with each outcome variable were entered in model. Next, one of independent variable that was the most no significant associated with each outcome variable was excluded, and so on. Then, in the final model of *backward method* was included one or more time-independent covariates that were significant associated with each outcome variable. However, in *forward method*, it would start from the model that was included only time-variable and group variable was defined as null model. Next, one of independent variable that was the most significant associated with each outcome variable in the univariate analysis was excluded, and so on. Then, in the final model of *forward method*, it was included one or more time-independent covariates that were significant associated with each outcome variable. Among each method, the model selection was used *the smallest standard deviation of the model* or *the smallest number of covariates* to be a criteria. Finally, models from three methods were compared by using the *"explained variance of the model"* (Twisk, 2003: 55-101), that was defined as;

$$F_{it} = 1 - \left(\frac{S^2_{\text{model}}}{S^2_Y}\right) \qquad (4.2)$$

where S^2_{model} was the variance of the model and S^2_Y was the variance of the outcome variable Y, calculated over all available data. The best model was the model that showed *the maximum explained variance* of the model. However, in case of S^2_{model} was more than S^2_Y, then an *explained variance of the model* would not calculate. Therefore, criteria of model selection would be used *the smallest standard deviation of the model* or *the smallest number of covariates.*

4.7.1. Weight for Age

For the model, intercept, the regression coefficient (beta) of time variable "VISITMONTH", group variable "HILLTRIBE" and time-independent covariates, and the corresponding p-value of regression coefficients were given. In addition, regression method, number of observation, Wald Chi-square statistic and the corresponding p-value, scale parameter, and the standard deviation of model were given.

Multivariate GEE models of outcome variable "WT" by using *enter method* were shown in Table 4.17.

From *enter method* with an exchangeable correlation structure in Table 4.17, three models were compared as following;

The first model was modeled by using *enter method* was fitted (p<0.001), the standard deviation of the model was 2.286;

*WT = -3.850 -0.094*VISITMONTH +0.100*HILLTRIBE -0.009*GESTATION +1.020*BWKG +0.027*BLT +0.021*BHEAD -0.086*PREGORDER +0.286*CHILDNO +0.073*DELIVER1 -0.006*DELIVER2 +0.008*AGEMOM +0.007*ANCTIME*

The 2nd model was modeled by using *enter method* was fitted (p<0.001), the standard deviation of the model was 2.334;

*WT = -2.517 -0.093*VISITMONTH +0.051*HILLTRIBE +1.073*BWKG +0.014*BLT -0.054*PREGORDER*

The 3rd model was modeled by using *enter method* was fitted (p<0.001), the standard deviation of the model was 2.330;

*WT = -1.983 -0.093*VISITMONTH +0.054*HILLTRIBE +1.135*BWKG -0.055*PREGORDER*

Table 4.17 Results from the Multivariate GEE Analysis of Weight for Age among Lowland and Hilltribe Children by Using *Enter Method*

Variables	Model					
	1st	p	2nd	p	3rd	p
Intercept	-3.850	<0.001**	-2.517	<0.001**	-1.983	<0.001**
VISITMONTH	-0.094	<0.001**	-0.093	<0.001**	-0.093	<0.001**
HILLTRIBE	0.100	0.211	0.051	0.487	0.054	0.464
GESTATION	-0.009	0.671				
BWKG	1.020	<0.001**	1.073	<0.001**	1.135	<0.001**
BLT	0.027	0.036**	0.014	0.200		
BHEAD	0.021	0.149				
PREGORDER	-0.086	0.017**	-0.054	0.043**	-0.055	0.036**
CHILDNO	0.286	0.238				
DELIVER1	0.073	0.408				
DELIVER2	-0.006	0.975				
AGEMOM	0.008	0.214				
ANCTIME	0.007	0.510				
Number of Observations	889		981		985	
Wald χ^2 for model fitting	898	<0.001**	924	<0.001**	926	<0.001**
Scale Parameter	1.512		1.528		1.526	
Standard Deviation of the Model	2.286		2.334		2.330	

** Significant level at 0.05.

According to Table 4.12, the first model was included nine time-independent covariates, GESTATION, BWKG, BLT, BHEAD, PREGORDER, CHILDNO, DELIVER1, DELIVER2, AGEMOM, and ANCTIME. Whereas, in the 2nd model was included three covariates; BWKG, BLT, and PREGORDER. The 3rd model was included only two covariates; BWKG, and PREGORDER. When three models by using *enter method* were compared, the first model was gave the least standard deviation of the model (2.286). When the non-significant covariate was excluded from the model, the standard deviation was increase. Number of covariates in the 3rd model was minimized, whereas the standard deviation was not so differ from the first model. Then the final model by using *enter method* was the 3rd model. Next the models by using *backward method* were compared.

Multivariate GEE models of outcome variable "WT" by using *backward method* were shown in Table 4.18. From *backward method*, the first model that was modeled by using *enter method* was the first consideration as following;

The first model was modeled by using *enter method* was fitted ($p<0.001$), the standard deviation of the model was 2.286;

*WT = -3.850 -0.094*VISITMONTH +0.100*HILLTRIBE -0.009*GESTATION +1.020*BWKG +0.027*BLT +0.021*BHEAD -0.086*PREGORDER +0.286*CHILDNO +0.073*DELIVER1 -0.006*DELIVER2 +0.008*AGEMOM +0.007*ANCTIME*

From **the first model**, the most not significant time-independent covariate DELIVER2, and DELIVER1 ($p=0.975$, and 0.480 respectively) were excluded. **The 4th model** was modeled by using *backward method* was fitted ($p<0.001$), the standard deviation of the model was 2.296.

*WT = -3.917 -0.094*VISITMONTH +0.101*HILLTRIBE -0.010*GESTATION +0.993*BWKG +0.029*BLT +0.024*BHEAD -0.087*PREGORDER +0.285*CHILDNO +0.008*AGEMOM +0.007*ANCTIME*

Next, from the 4th model, the most no significant time-independent covariate was GESTATION ($p=0.619$) was excluded. **The 5th model** was modeled by using *backward method* was fitted ($p<0.001$), the standard deviation of model was 2.301.

*WT = -4.154 -0.094*VISITMONTH +0.095*HILLTRIBE +0.980*BWKG +0.029*BLT +0.023*BHEAD -0.083*PREGORDER +0.250*CHILDNO +0.007*AGEMOM +0.007*ANCTIME*

Table 4.18 Results from the Multivariate GEE Analysis of Weight for Age among Lowland and Hilltribe Children by Using *Backward Method*

Variables	Model											
	1^{st}	p	4^{th}	p	5^{th}	p	6^{th}	p	7^{th}	p	8^{th}	p
Intercept	-3.850	<0.001**	-3.917	<0.001**	-4.154	<0.001**	-4.107	<0.001**	-3.835	<0.001**	-3.754	<0.001**
VISITMONTH	-0.094	<0.001**	-0.094	<0.001**	-0.094	<0.001**	-0.093	<0.001**	-0.093	<0.001**	-0.093	<0.001**
HILLTRIBE	0.100	0.211	0.101	0.205	0.095	0.228	0.056	0.464	0.059	0.439	0.041	0.580
GESTATION	-0.009	0.671	-0.010	0.619								
BWKG	1.020	<0.001**	0.993	<0.001**	0.980	<0.001**	0.961	<0.001**	0.957	<0.001**	0.957	<0.001**
BLT	0.027	0.036**	0.029	0.022**	0.029	0.024**	0.025	0.039**	0.025	0.039**	0.026	0.037**
BHEAD	0.021	0.149	0.024	0.084	0.023	0.090	0.029	0.036**	0.029	0.035**	0.031	0.027**
PREGORDER	-0.086	0.017**	-0.087	0.013**	-0.083	0.019**	-0.075	0.018**	-0.074	0.018**	-0.052	0.048**
CHILDNO	0.286	0.238	0.285	0.235	0.250	0.258	0.257	0.253				
DELIVER1	0.073	0.408										
DELIVER2	-0.006	0.975										
AGEMOM	0.008	0.214	0.008	0.213	0.007	0.267	0.007	0.200	0.007	0.199		
ANCTIME	0.007	0.510	0.007	0.513	0.007	0.478						
Number of Observations	889		900		920		977		978		981	
Wald χ^2 for model fitting	898	<0.001**	889	<0.001**	920	<0.001**	931	<0.001**	930	<0.001**	933	<0.001**
Scale Parameter	1.512		1.515		1.517		1.522		1.524		1.524	
Standard Deviation of the Model	2.286		2.296		2.301		2.317		2.324		2.323	

** Significant level at 0.05

From the 5th model, the most no significant time-independent covariate was ANCTIME (p=0.478) was excluded. **The 6th model** was modeled by using *backward method* was fitted (p<0.001), the standard deviation of model was 2.317.

$$WT = -4.107 -0.093*VISITMONTH +0.056*HILLTRIBE +0.961*BWKG +0.025*BLT +0.029*BHEAD -0.075*PREGORDER +0.257*CHILDNO +0.007*AGEMOM$$

From the 6th model, the most no significant time-independent covariate was CHILDNO (p=0.253) was excluded. **The 7th model** was modeled by using *backward method* was fitted (p<0.001), the standard deviation of model was 2.324.

$$WT = -3.835 -0.093*VISITMONTH +0.059*HILLTRIBE +0.957*BWKG +0.025*BLT +0.029*BHEAD -0.074*PREGORDER +0.007*AGEMOM$$

Lastly, most no significant time-independent covariate AGEMOM (p=0.199) in the 7th model was excluded. **The 8th model** was modeled by using *backward method* was fitted (p<0.001), and the standard deviation of model was 2.323.

$$WT = -3.754 -0.093*VISITMONTH +0.041*HILLTRIBE +0.957*BWKG +0.026*BLT +0.031*BHEAD -0.052*PREGORDER$$

When six models by using *backward method* were compared in Table 4.18, standard deviations of the model were slightly difference. The first model that included all of significant covariates from the univariate analysis, was gave the least standard deviation of the model (2.286), but still contained many non-significant covariates in multivariate model. From *backward method*, when the most non-significant covariate in multivariate model was removed, the standard deviation of the model was increased. In the 8th model did not contain non-significant covariates, and the standard deviation of the model was slightly differ from the first model. Then the final model by using *backward method* was the 8th model. Next step was model comparison by using *forward method*.

According to the results of the univariate GEE analysis in Table 4.12, there were nine time-independent covariates that were significant associated with outcome variable WT among lowland or hilltribe children. The most significant associated with outcome variable WT would be the first covariate considered in the multivariate model. If model was fitted, next order would be considered, and so on. By descending significant, there were BWKG, BLT, BHEAD, GESTATION, AGEMOM, CHILDNO, ANCTIME, DELIVER1, DELIVER2, and PREGORDER respectively.

Then the multivariate GEE models of outcome variable “WT” by using *forward method* were shown in Table 4.19.

From *forward method*, two models were compared was following;

The 9th model was modeled by using *forward method* was fitted ($p<0.001$), time-independent covariate BWKG was considered. The standard deviation of the model was 2.330.

*WT = -2.066 -0.094*VISITMONTH +0.010*HILLTRIBE +1.135*BWKG*

The 10th model was modeled by using *forward method* was fitted ($p<0.001$), time-independent covariate BLT was additional considered. The standard deviation of model was a slightly increased (2.333). However, there was one time-independent covariate, BLT, was non-significant associated with WT then the process was stopped.

*WT = -2.636 -0.093*VISITMONTH +0.008*HILLTRIBE +1.068*BWKG +0.015*BLT*

Since models comparison, the standard deviation of model would be increased when one time-independent covariate was added. The 9th model was gave the least standard deviation of the model and all covariates were significant associated with WT. While as, the 10th model was gave the Standard Deviation of the Model more than the 9th model, and contained the covariate that was not significant associated with WT. Thus the final model by using *forward method* was the 9th model.

Table 4.19 Results from the Multivariate GEE Analysis of Weight for Age among Lowland and Hilltribe Children by Using *Forward Method*

Variables	Model			
	9^{th}	p	10^{th}	p
Intercept	-2.066	<0.001**	-2.636	<0.001**
VISITMONTH	-0.094	<0.001**	-0.093	<0.001**
HILLTRIBE	0.010	0.888	0.008	0.908
GESTATION				
BWKG	1.135	<0.001**	1.068	<0.001**
BLT			0.015	0.169
BHEAD				
PREGORDER				
CHILDNO				
DELIVER1				
DELIVER2				
AGEMOM				
ANCTIME				
Number of Observations	999		995	
Wald χ^2 for model fitting	950	<0.001**	948	<0.001**
Scale Parameter	1.526		1.527	
Standard Deviation of the Model	2.330		2.333	

** Significant level at 0.05.

Between three methods; *enter*, *backward* and *forward method* were gave difference final model as showed in Table 4.20.

Table 4.20 Final Model from the Multivariate GEE Analysis of Weight for Age among Lowland and Hilltribe Children, Three Methods Comparison

Variables	Method					
	Enter	p	Backward	p	Forward	p
Intercept	-1.983	<0.001**	-3.754	<0.001**	-2.066	<0.001**
VISITMONTH	-0.093	<0.001**	-0.093	<0.001**	-0.094	<0.001**
HILLTRIBE	0.054	0.464	0.041	0.580	0.010	0.888
GESTATION						
BWKG	1.135	<0.001**	0.957	<0.001**	1.135	<0.001**
BLT			0.026	0.037**		
BHEAD			0.031	0.027**		
PREGORDER	-0.055	0.036**	-0.052	0.048**		
CHILDNO						
DELIVER1						
DELIVER2						
AGEMOM						
ANCTIME						
Number of Observations	985		981		999	
Wald χ^2 for model fitting	926	<0.001**	933	<0.001**	950	<0.001**
Scale Parameter	1.526		1.524		1.526	
Standard Deviation of the Model	2.330		2.323		2.330	
F_{it}	–[†]		–[†]		–[†]	

** Significant level at 0.05.
[†]Unavailable because variance of the model more than variance of the outcome variable.

All models from difference methods were fitted (p<0.001). The GEE model using different methods were gave the different model. Due to the explained variance of the model (F_{it}) that would be used for model selection, but in this part, F_{it} could not calculated because variance of the model more than variance of the outcome variable “WT”. Then the model selection would be used the least standard deviation of the model or the minimized number of time-independent covariates. When standard deviation of the model was considered, the models from three methods were gave similar standard deviation of the model. However, model using *backward* *method* was the least standard deviation of the model. Thus model using *backward method* was a final model that appropriated to predict outcome variable “WT”.

In conclusion, from Table 4.20 weight for age z-score was a bit different among lowland and hilltribe children, but were not significant (β=0.041, p=0.580). Weight for age z-score was significant negative associated with visit months (β=-0.093, p<0.001). If age of children was considered as visit months, then weight for age was decreased when a child was grew up. However, the factor that effected to weight for age of children was birth weight, birth length, birth head circumference, and pregnancy order. Birth weight, birth length, and birth head circumference were significant positive associated with weight for age z-score (β=0.957, p<0.001; β=0.026, p=0.037; and β=0.031, p=0.027 respectively). In the other hand, pregnancy order was significant negative associated with weight for age z-score (β=-0.052, p=0.048). From these results, the GEE model that would explain the growth pattern by using weight for age as a growth indices as following.

Lowland children;

*WT = -3.754 -0.093*VISITMONTH +0.957*BWKG +0.026*BLT +0.031*BHEAD -0.052*PREGORDER*

Hilltribe children;

*WT = -3.713 -0.093*VISITMONTH +0.957*BWKG +0.026*BLT +0.031*BHEAD -0.052*PREGORDER*

Weight for age z-scores of lowland and hilltribe children, when birth weight, birth length, birth head circumference, and pregnancy order were controlled, were shown in Figure 4.11. Weight for age z-scores of both groups will decrease after birth but hilltribe children will almost more than lowland. In the first year of life, weight for age z-scores will be more than the reference, and later will be less than.

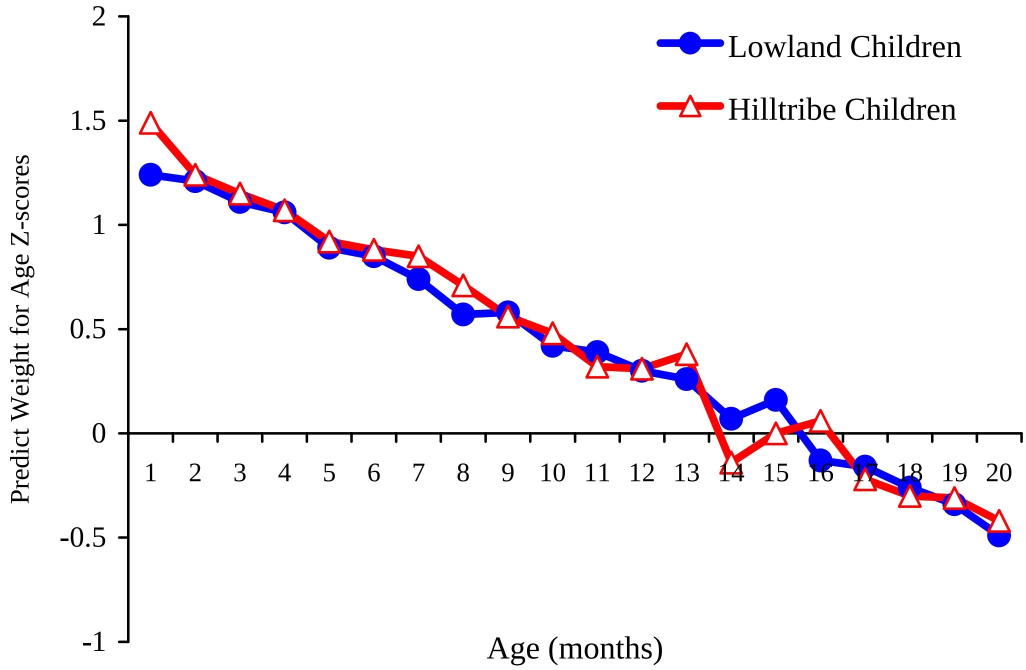

Figure 4.12 Predict Weight for Age Z-scores of Lowland and Hilltribe Children

4.7.2 Length for Age

Multivariate GEE models of outcome variable "LT" by using *enter method* were shown in Table 4.21.

When two models using *enter method* were compared as in Table 4.21, all models were fitted ($p<0.001$). The 2nd model was determined the least standard deviation of model (2.952) and the number of time-independent covariates was less than the 1st model. Thus the 2nd model was a final model that appropriated to predict LT by using *enter method*.

*LT = -1.703 -0.056*VISITMONTH -0.050*HILLTRIBE +0.851*BWKG - 0.150*PREGORDER*

Table 4.21 Results from the Multivariate GEE Analysis of Length for Age among Lowland and Hilltribe Children by Using *Enter Method*

Variables	Model			
	1st	p	2nd	p
Intercept	-3.045	0.118	-1.703	<0.001**
VISITMONTH	-0.055	<0.001**	-0.056	<0.001**
HILLTRIBE	-0.081	0.597	-0.050	0.609
GESTATION	-0.038	0.276		
BWKG	0.790	0.001**	0.851	<0.001**
BLT	0.028	0.270		
BHEAD	0.047	0.134		
PREGORDER	-0.185	0.031**	-0.150	<0.001**
CHILDORDER	0.002	0.985		
BIRTHSPACE	-0.013	0.588		
DELIVER1	-0.236	0.123		
DELIVER2	-0.408	0.432		
AGEMOM	0.009	0.589		
ANCTIME	0.008	0.667		
Number of Observations	325		822	
Wald χ^2 for model fitting	179	<0.001**	298	<0.001**
Scale Parameter	1.817		1.718	
Standard Deviation of the Model	3.302		2.952	

** Significant level at 0.05.

Multivariate GEE models of outcome variable "LT" by using *backward method* were shown in Table 4.22. Firstly, the 1st model was modeled by using *enter method*, included only significant covariates with LT from the univariate analysis. The most non-significant covariate would be excluded from model and so on. The 3rd to 10th model were modeled by using *backward method*. When every one of non-significant covariate was removed from the 3rd, 4th, and 9th model, the standard deviation of the model was slightly decreased. Conversely, the standard deviation of the model was slightly increased again when the most non-significant was removed from the 5th, 6th, 7th, 8th, and 10th model. Although the 5th model was gave the least standard deviation, but still contained many non-significant covariates. When all of models using *backward method* were compared, the 10th model was contained the least covariate and all were significant associated with LT. The standard deviation of the 10th model was a bit more than the other, so the final model by using *backward method* was the 10th model.

*LT = -1.703 -0.056*VISITMONTH -0.050*HILLTRIBE +0.851*BWKG -0.150*PREGORDER*

Next the models that constructed by using *forward method* were compared.

According to the results of the univariate GEE analysis in Table 4.13, there were eleven time-independent covariates that were significant associated with outcome variable LT among lowland or hilltribe children. By descending significant, there were BWKG, PREGORDER, GESTATION, CHILDORDER, BLT, AGEMOM, BHEAD, ANCTIME, DELIVER1, DELIVER2, and BIRTHSPACE respectively.

The most significant associated with outcome variable LT would be the first covariate considered in the multivariate model. If the model was fitted, next order would be considered, and so on. Then the multivariate GEE model of outcome variable “WT” by using *forward method* was shown in Table 4.23.

There were three models using *forward method* were compared. In the 11th model was included only the most significant covariate in the univariate analysis, BWKG. In the 12th model, covariate PREGORDER was added, and this covariate was significant associated with LT. Then covariate GESTATION was added in the 13th model, but was not associated with LT, so the process was stopped. When the standard deviation of the model was considered, the 13th model was the least standard deviation of model but this model contained the covariate that was not significant. Therefore, the 12th model was the second rank of the least standard deviation of the model and all of covariates in the model were significant associated with LT. Thus the final model for *forward method* was the 12th model.

*LT = -1.703 -0.056*VISITMONTH -0.050*HILLTRIBE +0.851*BWKG -0.150*PREGORDER*

Table 4.22 Results from the Multivariate GEE Analysis of Length for Age among Lowland and Hilltribe Children by Using *Backward Method*

Variables	Model 1st	p	3rd	p	4th	p	5th	p	6th	p	7th	p	8th	p	9th	p	10th	p
Intercept	-3.045	0.118	-2.718	0.113	-2.556	0.136	-5.251	<0.001**	-5.038	<0.001**	-3.909	<0.001**	-3.885	<0.001**	-3.171	<0.001**	-1.703	<0.001**
VISITMONTH	-0.055	<0.001**	-0.058	<0.001**	-0.058	<0.001**	-0.058	<0.001**	-0.057	<0.001**	-0.057	<0.001**	-0.057	<0.001**	-0.057	<0.001**	-0.056	<0.001**
HILLTRIBE	-0.081	0.597	-0.058	0.652	-0.060	0.636	-0.081	0.376	-0.091	0.318	-0.080	0.377	-0.100	0.273	-0.091	0.316	-0.050	0.609
GESTATION	-0.038	0.276	-0.024	0.451	-0.027	0.389	0.033	0.125	0.034	0.097	0.036	0.081	0.038	0.060	0.039	0.055		
BWKG	0.790	0.001**	0.854	<0.001**	0.858	<0.001**	0.689	<0.001**	0.678	<0.001**	0.787	<0.001**	0.764	<0.001**	0.831	<0.001**	0.851	<0.001**
BLT	0.028	0.270	0.021	0.338	0.022	0.324	0.031	0.033**	0.030	0.034**	0.020	0.117	0.019	0.144				
BHEAD	0.047	0.134	0.024	0.389	0.024	0.383	0.034	0.076	0.031	0.103								
PREGORDER	-0.185	0.031**	-0.167	0.003**	-0.158	<0.001**	-0.125	<0.001**	-0.135	<0.001**	-0.137	<0.001**	-0.146	<0.001**	-0.148	<0.001**	-0.150	<0.001**
CHILDORDER	0.002	0.985																
BIRTHSPACE	-0.013	0.588	-0.007	0.753	-0.003	0.847												
DELIVER1	-0.236	0.123	-0.172	0.212	-0.168	0.215	-0.170	0.087	-0.115	0.239	-0.082	0.386						
DELIVER2	-0.408	0.432	-0.382	0.324	-0.393	0.313	-0.401	0.167	-0.544	0.047**	-0.521	0.057						
AGEMOM	0.009	0.589	0.005	0.770														
ANCTIME	0.008	0.667	0.010	0.524	0.010	0.523	0.006	0.572										
Number of Observations	325		379		382		748		787		787		795		798		822	
Wald χ^2 for model fitting	179	<0.001**	209	<0.001**	214	<0.001**	336	<0.001**	348	<0.001**	337	<0.001**	315	<0.001**	314	<0.001**	298	<0.001**
Scale Parameter	1.817		1.794		1.785		1.610		1.631		1.636		1.665		1.661		1.718	
Standard Deviation of the Model	3.302		3.218		3.186		2.593		2.661		2.677		2.772		2.760		2.952	

** Significant level at 0.05

Table 4.23 Results from the Multivariate GEE Analysis of Length for Age among Lowland and Hilltribe Children by Using *Forward Method*

Variables	Model					
	11th	p	12th	p	13th	p
Intercept	-1.914	<0.001**	-1.703	<0.001**	-3.171	<0.001**
VISITMONTH	-0.058	<0.001**	-0.056	<0.001**	-0.057	<0.001**
HILLTRIBE	-0.150	0.099	-0.050	0.609	-0.091	0.316
GESTATION					0.039	0.055
BWKG	0.841	<0.001**	0.851	<0.001**	0.831	<0.001**
BLT						
BHEAD						
PREGORDER			-0.150	<0.001**	-0.148	<0.001**
CHILDORDER						
BIRTHSPACE						
DELIVER1						
DELIVER2						
AGEMOM						
ANCTIME						
Number of Observations	836		822		798	
Wald χ^2 for model fitting	271	<0.001**	298	<0.001**	314	<0.001**
Scale Parameter	1.743		1.718		1.661	
Standard Deviation of the Model	3.037		2.952		2.760	

** Significant level at 0.05.

Between three methods; *enter*, *backward and forward method* were gave the same final model to predict outcome variable “LT” as showed in Table 4.24. The model was fitted (p<0.001) and included only two time-independent covariates; BWKG and PREGORDER.

Table 4.24 Final Model from the Multivariate GEE Analysis of Length for Age among Lowland and Hilltribe Children, Three Methods Comparison

Variables	Model					
	Enter	p	Backward	p	Forward	p
Intercept	-1.703	<0.001**	-1.703	<0.001**	-1.703	<0.001**
VISITMONTH	-0.056	<0.001**	-0.056	<0.001**	-0.056	<0.001**
HILLTRIBE	-0.050	0.609	-0.050	0.609	-0.050	0.609
GESTATION						
BWKG	0.851	<0.001**	0.851	<0.001**	0.851	<0.001**
BLT						
BHEAD						
PREGORDER	-0.150	<0.001**	-0.150	<0.001**	-0.150	<0.001**
CHILDORDER						
BIRTHSPACE						
DELIVER1						
DELIVER2						
AGEMOM						
ANCTIME						
Number of Observations	822		822		822	
Wald χ^2 for model fitting	298	<0.001**	298	<0.001**	298	<0.001**
Scale Parameter	1.718		1.718		1.718	
Standard deviation of the model	2.952		2.952		2.952	
F_{it}	–[†]		–[†]		–[†]	

** Significant level at 0.05.
[†]Unavailable because variance of the model more than variance of the outcome variable.

In conclusion, from Table 4.24 there were not different among lowland and hilltribe children (β=-0.050, p=0.609). Height for age z-score was significant negative associated with visit months (β=-0.056, p<0.001). If age of children was considered as visit months, it was means that height for age was decreased when a child was grew up. However, the factors that effected to length for age z-score of children were birth weight and pregnancy order. Birth weight was significant positive associated with length for age z-score (β=0.851, p<0.001). In contrast, pregnancy order was significant negative associated with length for age z-score (β=-0.150, p<0.001). From these results, the GEE model that would explain the growth pattern by using length for age as a growth indices as following.

Lowland children;

*LT = -1.703 -0.056*VISITMONTH +0.851*BWKG -0.150*PREGORDER*

Hilltribe children;

*LT = -1.753 -0.056*VISITMONTH +0.851*BWKG -0.150*PREGORDER*

From Figure 4.12 was shown length for age z-scores of lowland and hilltribe children, when birth weight, and pregnancy order were controlled. Length for age z-scores of both groups will decrease after birth but lowland children will almost higher than hilltribe. In the first nine months of hilltribe children, weight for age z-scores will be higher than the reference, and later will be lower than. While as, weight for age z-scores in the twelve months of lowland children will be higher than the reference, and later will be lower than.

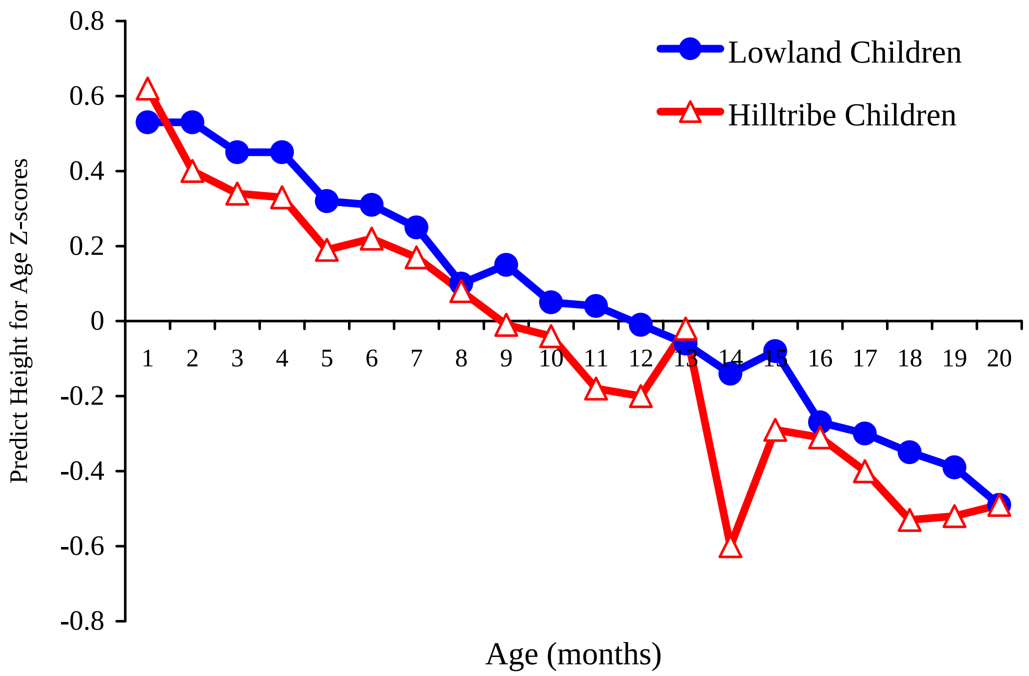

Figure 4.13 Predict Length for Age Z-scores of Lowland and Hilltribe Children

4.7.3 Head Circumference for Age

Multivariate GEE models of outcome variable "HEAD" by using *enter method* were shown in Table 4.25.

Table 4.25 Results from the Multivariate GEE Analysis of Head Circumference for Age among Lowland and Hilltribe Children Using *Enter Method*

Variables	Model			
	1st	p	2nd	p
Intercept	-7.276	0.020**	1.260	<0.001**
VISITMONTH	-0.093	<0.001**	-0.096	<0.001**
HILLTRIBE	0.276	0.028**	0.124	0.368
FEMALE	-0.225	0.200		
GESTATION	-0.003	0.961		
BWKG	0.267	0.541		
BLT	0.084	0.299		
BPONDERAL	0.018	0.593		
BHEAD	0.078	0.204		
PREGORDER	0.045	0.653		
BIRTHSPACE	-0.057	0.072		
DELIVER1	0.299	0.250		
DELIVER2	0.154	0.617		
AGEMOM1	0.837	0.016**	0.246	0.108
AGEMOM2	1.018	0.014**	0.301	0.129
AGEMOM3	0.028	0.967	-0.986	0.069
Number of Observations	115		248	
Wald χ^2 for model fitting	307	<0.001**	277	<0.001**
Scale Parameter	1.289		1.291	
Standard Deviation of the Model	1.661		1.666	

** Significant level at 0.05.

When two models using *enter method* were compared, all model were fitted (p<0.001). In the 2nd model, the number of time-independent covariates was less than 1st model, though the standard deviation of model was slightly more than. Thus the 2nd model was a final model to predict HEAD using *enter method*.

*HEAD = 1.260 -0.096*VISITMONTH +0.124*HILLTRIBE +0.246*AGEMOM1 +0.301*AGEMOM2 -0.986*AGEMOM3*

Multivariate GEE models of outcome variable "HEAD" by using *backward method* were shown in Table 4.26.

Firstly, the 1st model was modeled by using *enter method*, only significant covariates with LT from the univariate analysis were considered. The most non-significant covariate would be excluded from model and so on. The 3rd to 8th model were modeled by using *backward method*. According to model by using *backward method*, when one of covariate was removed from model, the standard deviation of model was changed. In the 3rd model was contained the maximum number of covariates. The 3rd and 4th model were the least standard deviation of model, but still contained the non-significant covariate. When the most non-significant covariate was removed from the model, the standard deviation of the model was slightly increased. While as, the 8th model was contained the minimum number of covariates and the standard deviation of the model was slightly more than others. Then the final model by using *backward method* was the 8th model.

*HEAD = -8.069 -0.094*VISITMONTH +0.243*HILLTRIBE +0.082*BLT +0.148*BHEAD -0.060*BIRTHSPACE +0.705*AGEMOM1 +0.929*AGEMOM2 -0.054*AGEMOM3*

Table 4.26 Results from the Multivariate GEE Analysis of Head Circumference for Age among Lowland and Hilltribe Children Using *Backward Method*

Variables	Model 1st	p	3rd	p	4th	p	5th	p	6th	p	7th	p	8th	p
Intercept	-7.276	0.020**	-7.369	0.008**	-6.943	0.004**	-6.083	<0.001**	-6.494	<0.001**	-7.458	<0.001**	-8.069	<0.001**
VISITMONTH	-0.093	<0.001**	-0.094	<0.001**	-0.093	<0.001**	-0.093	<0.001**	-0.094	<0.001**	-0.094	<0.001**	-0.094	<0.001**
HILLTRIBE	0.276	0.028**	0.277	0.211	0.302	0.128	0.296	0.138	0.269	0.184	0.244	0.222	0.243	0.224
FEMALE	-0.225	0.200	-0.222	0.201	-0.238	0.169	-0.234	0.177	-0.266	0.120	-0.269	0.117		
GESTATION	-0.003	0.961												
BWKG	0.267	0.541	0.258	0.548	0.282	0.502	0.410	0.182	0.294	0.299				
BLT	0.084	0.299	0.085	0.288	0.076	0.303	0.044	0.111	0.056	0.036	0.079	<0.001**	0.082	<0.001**
BPONDERAL	0.018	0.593	0.020	0.562	0.016	0.617								
BHEAD	0.078	0.204	0.076	0.215	0.080	0.181	0.104	<0.001**	0.114	<0.001**	0.137	<0.001**	0.148	<0.001**
PREGORDER	0.045	0.653	0.045	0.653										
BIRTHSPACE	-0.057	0.072	-0.058	0.065	-0.063	0.014**	-0.062	0.016**	-0.063	0.015**	-0.061	0.019**	-0.060	0.023**
DELIVER1	0.299	0.250	0.302	0.242	0.291	0.255	0.283	0.268						
DELIVER2	0.154	0.617	0.158	0.605	0.185	0.561	0.188	0.571						
AGEMOM1	0.837	0.016**	0.838	0.015**	0.889	0.003**	0.871	0.004**	0.786	0.019**	0.744	0.025**	0.705	0.046**
AGEMOM2	1.018	0.014**	1.024	0.013**	1.109	0.001**	1.087	0.001**	1.002	0.007**	0.949	0.010**	0.929	0.018**
AGEMOM3	0.028	0.967	0.039	0.954	0.200	0.689	0.165	0.741	0.023	0.965	-0.057	0.918	-0.054	0.926
Number of Observations	115		116		117		117		117		117		117	
Wald χ^2 for model fitting	307	<0.001**	311	<0.001**	306	<0.001**	176	<0.001**	173	<0.001**	172	<0.001**	159	<0.001**
Scale Parameter	1.289		1.285		1.285		1.287		1.299		1.302		1.314	
Standard Deviation of the Model	1.661		1.650		1.650		1.655		1.688		1.695		1.727	

** Significant level at 0.05

Next the models by using *forward method* were compared. According to the results of the univariate GEE analysis in Table 4.14, there were thirteen time-independent covariates that were significant associated with outcome variable HEAD among lowland or hilltribe children. By descending significant, there were BWKG, BHEAD, DELIVER1, DELIVER2, BPONDERAL, BLT, FEMALE, GESTATION, AGEMOM1, AGEMOM2, AGEMOM3, BIRTHSPACE, and PREGORDER respectively.

The most significant associated with outcome variable HEAD would be the first covariate considered in the multivariate model. If the model was fitted, next order of covariates would be considered, and so on. If the model was not fitted or some covariate would not significant, the process would stop. Then the multivariate GEE model of outcome variable "HEAD" by using *forward method* was shown in Table 4.26.

There were four models using *forward method* were compared, all models are fitted ($p<0.010$). The 9th model was the initial model, in this only the most significant covariate in the univariate analysis, BWKG was included. In the 10th model, covariates BWKG and BHEAD were added, and both were significant associated with HEAD. Then covariates BWKG, BHEAD, DELIVER1, and DELIVER2 were added in the 11th model, also all of them were significant associated with HEAD. After that, covariate BPONDERAL was added in the 12th model, and this covariate was not significant associated with HEAD. Then the process was stopped. When the standard deviation of the model was considered, the least standard deviations of model were the 12th, 11th, 10th, and 9th model respectively. The standard deviation of model would decreased when more covariate were added. Whatever, the 12th model was gave the least standard deviation of model, but contained the non-significant covariate. Thus the final model for *forward method* was the 11th model.

$$HEAD = -3.519 - 0.096*VISITMONTH + 0.110*HILLTRIBE + 0.677*BWKG + 0.087*BHEAD + 0.325*DELIVER1 + 0.363*DELIVER2$$

Table 4.27 Results from the Multivariate GEE Analysis of Head Circumference for Age among Lowland and Hilltribe Children Using *Forward Method*

Variables	Model							
	9th	p	10th	p	11th	p	12th	p
Intercept	-1.247	0.020**	-3.768	<0.001**	-3.519	<0.001**	-3.997	<0.001**
VISITMONTH	-0.096	<0.001**	-0.096	<0.001**	-0.096	<0.001**	-0.096	<0.001**
HILLTRIBE	0.097	0.465	0.084	0.518	0.110	0.398	0.072	0.574
FEMALE								
GESTATION								
BWKG	0.874	<0.001**	0.675	<0.001**	0.677	<0.001**	0.638	<0.001**
BLT								
BPONDERAL							-0.014	0.228
BHEAD			0.097	0.005**	0.087	0.002**	0.116	0.003**
PREGORDER								
BIRTHSPACE								
DELIVER1					0.325	0.012**	0.308	0.022**
DELIVER2					0.363	0.348	0.348	0.370
AGEMOM1								
AGEMOM2								
AGEMOM3								
Number of Observations	251		251		251		249	
Wald χ^2 for model fitting	305	<0.001**	306	<0.001**	325	<0.001**	318	<0.001**
Scale Parameter	1.251		1.221		1.202		1.200	
Standard Deviation of the Model	1.564		1.490		1.445		1.440	

** Significant level at 0.05.

Between three methods; *enter, backward and forward method* were gave difference final model as showed in Table 4.28.

Table 4.28 Final Model from the Multivariate GEE Analysis of Head Circumference for Age among Lowland and Hilltribe Children, Three Methods Comparison

Variables	Model					
	Enter	p	Backward	p	Forward	p
Intercept	1.260	<0.001**	-8.069	<0.001**	-3.519	<0.001**
VISITMONTH	-0.096	<0.001**	-0.094	<0.001**	-0.096	<0.001**
HILLTRIBE	0.124	0.368	0.243	0.224	0.110	0.398
FEMALE						
GESTATION						
BWKG					0.677	<0.001**
BLT			0.082	<0.001**		
BPONDERAL						
BHEAD			0.148	<0.001**	0.087	0.002**
PREGORDER						
BIRTHSPACE			-0.060	0.023**		
DELIVER1					0.325	0.012**
DELIVER2					0.363	0.348
AGEMOM1	0.246	0.108	0.705	0.046**		
AGEMOM2	0.301	0.129	0.929	0.018**		
AGEMOM3	-0.986	0.069	-0.054	0.926		
Number of Observations	248		117		251	
Wald χ^2 for model fitting	277	<0.001**	159	<0.001**	325	<0.001**
Scale Parameter	1.291		1.314		1.202	
Standard Deviation of the Model	1.666		1.727		1.445	
F_{it}	–[†]		–[†]		–[†]	

** Significant level at 0.05.
[†]Unavailable because variance of the model more than variance of the outcome variable.

All models from difference methods were fitted (p<0.001). The model using *enter method* was included time-independent covariates; AGEMOM1, AGEMOM2 and AGEMOM3. Where as, the model using *backward method* were included covariates; BLT, BHEAD, BIRTHSPACE, AGEMOM1, AGEMOM2 and

AGEMOM3. The model using forward method were included covariates; BWKG, BHEAD, DELIVER1, and DELIVER2. The standard deviation of the model using *forward method* was the least, and all of covariates were significant associated with HEAD. Then model using *forward method* was a final model that appropriated to predict outcome variable “HEAD”.

In conclusion, from Table 4.28 head circumference was a bit different between lowland and hilltribe children, but was not significant (β=0.110, p=0.398). However, head circumferenc for age z-score was significant negative associated with visit months (β=-0.096, p<0.001). If age of children was considered as visit months, it was means that head circumference for age was decreased when a child was grew up. The factors affected to head circumference of children were birth weight, birth head circumference, and delivery method. Birth weight, and birth head circumference were significant positive associated with head circumference for age z-score (β=0.677, p<0.001 and β=0.087, p=0.002 respectively). The children who were delivered by cesarean section would have head circumference for age z-score more than the children who were delivered normally (β=0.325, p=0.012). From these results, the GEE model that would explain the growth pattern by using head circumference for age as a growth indices as following.

Lowland children;

*LT = -3.519 -0.096*VISITMONTH +0.677*BWKG +0.087*BHEAD +0.325*DELIVER1 +0.363*DELIVER2*

Hilltribe children;

*LT = -3.409 -0.096*VISITMONTH +0.677*BWKG +0.087*BHEAD +0.325*DELIVER1 +0.363*DELIVER2*

The pattern of predict head circumference for age z-scores among lowland and hilltribe children after controlled birth weight, birth head circumference, and delivery method were disclosed in Figure 4.14. Head circumference for age z-scores of hilltribe children will be almost higher than lowland. The change of head circumference for age z-scores will be decrease after birth. In the fist sixteen months of age, the head circumference for age z-scores will be higher than national reference of Thailand. After that the head circumference for age z-scores will be lower than reference.

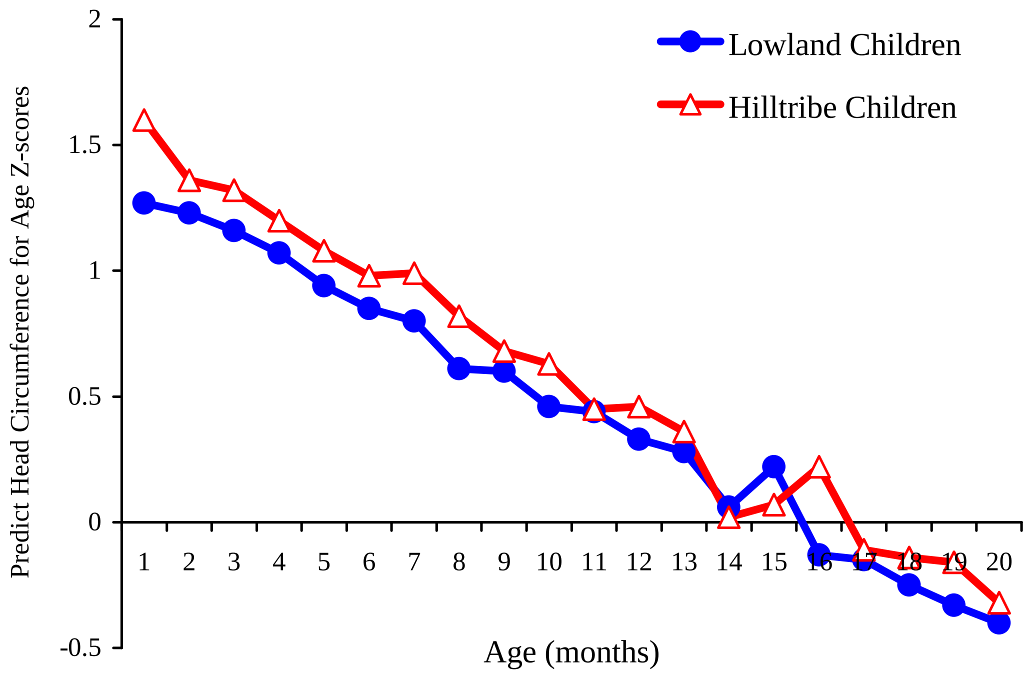

Figure 4.14 Predict Head Circumference for Age Z-score of Lowland and Hilltribe Children

4.7.4 Ponderal Index

Multivariate GEE models of outcome variable "PONDERAL" by using *enter method* were shown in Table 4.29.

The two models using *enter method* were compared, both models were fitted ($p<0.001$). The first model was the least standard deviation of model, but most of time-independent covariates in model were not significant associated with PONDERAL. In the 2^{nd} model, only covariate HIVMOMPOS was included. Thus the 2^{nd} model was a final model using *enter method* to predict PONDERAL.

$$PONDERAL = 30.407 - 0.526*VISITMONTH + 0.429*HILLTRIBE - 1.138*HIVMOMPOS$$

Table 4.29 Results from the Multivariate GEE Analysis of Ponderal Index among Lowland and Hilltribe Children Using *Enter Method*

Variables	Model			
	1st	p	2nd	p
Intercept	36.825	<0.001**	30.407	<0.001**
VISITMONTH	-0.520	<0.001**	-0.526	<0.001**
HILLTRIBE	0.541	0.144	0.429	0.160
FEMALE	-0.391	0.151		
GESTATION	-0.096	0.252		
BPONDERAL	0.020	0.297		
BHEAD	-0.091	0.227		
PREGORDER	0.041	0.912		
CHILDORDER	0.382	0.325		
CHILDNO	-1.117	0.156		
DELIVER1	0.407	0.219		
DELIVER2	1.276	0.410		
AGEMOM	0.007	0.804		
HIVMOMPOS	-1.338	0.011**	-1.138	0.029**
Number of Observations	725		861	
Wald χ^2 for model fitting	1,237	<0.001**	1,176	<0.001**
Scale Parameter	24.560		27.846	
Standard Deviation of the Model	603.196		775.396	

** Significant level at 0.05.

Multivariate GEE models of outcome variable “PONDERAL” by using *backward method* were shown in Table 4.30

Table 4.30 Results from the Multivariate GEE Analysis of Ponderal Index among Lowland and Hilltribe Children Using *Backward Method*

Variables	Model																	
	1st	p	3rd	p	4th	p	5th	p	6th	p	7th	p	8th	p	9th	p	10th	p
Intercept	36.825	<0.001**	36.790	<0.001**	36.897	<0.001**	36.197	<0.001**	35.586	<0.001**	34.724	<0.001**	33.749	<0.001**	29.588	<0.001**	29.390	<0.001**
VISITMONTH	-0.520	<0.001**	-0.520	<0.001**	-0.520	<0.001**	-0.520	<0.001**	-0.523	<0.001**	-0.523	<0.001**	-0.523	<0.001**	-0.521	<0.001**	-0.521	<0.001**
HILLTRIBE	0.541	0.144	0.503	0.176	0.482	0.182	0.470	0.182	0.420	0.229	0.406	0.244	0.392	0.259	0.258	0.467	0.250	0.481
FEMALE	-0.391	0.151	-0.412	0.133	-0.414	0.130	-0.418	0.124	-0.394	0.144	-0.375	0.164	-0.368	0.171	-0.364	0.178		
GESTATION	-0.096	0.252	-0.096	0.243	-0.095	0.245	-0.094	0.246	-0.099	0.221	-0.106	0.191	-0.104	0.197				
BPONDERAL	0.020	0.297	0.019	0.305	0.020	0.300	0.017	0.368										
BHEAD	-0.091	0.227	-0.090	0.232	-0.090	0.233	-0.072	0.323	-0.034	0.448								
PREGORDER	0.041	0.912																
CHILDORDER	0.382	0.325	0.430	0.017**	0.461	0.005**	0.489	0.002**	0.497	0.002**	0.496	0.002**	0.493	0.002**	0.539	0.001**	0.554	0.001**
CHILDNO	-1.117	0.156	-1.114	0.159	-1.113	0.159	-0.955	0.186	-0.933	0.197	-0.912	0.203						
DELIVER1	0.407	0.219	0.408	0.229	0.417	0.214												
DELIVER2	1.276	0.410	1.278	0.408	1.279	0.408												
AGEMOM	0.007	0.804	0.008	0.778														
HIVMOMPOS	-1.338	0.011**	-1.333	0.010**	-1.330	0.010**	-1.288	0.012**	-1.253	0.014**	-1.265	0.013**	-1.252	0.014**	-1.214	0.017**	-1.171	0.022**
Number of Observations	725		727		728		735		739		740		741		762		762	
Wald χ^2 for model fitting	1,237	<0.001**	1,231	<0.001**	1,216	<0.001**	1,205	<0.001**	1,212	<0.001**	1,191	<0.001**	1,193	<0.001**	1,207	<0.001**	1,207	<0.001**
Scale Parameter	24.560		24.569		24.569		24.564		24.629		24.612		24.608		24.629		24.662	
Standard Deviation of the Model	603.196		603.628		603.628		603.368		606.588		605.740		605.544		606.580		608.222	

** Significant level at 0.05

Firstly, the 1st model was modeled by using *enter method*, included only significant covariates with LT in univariate analysis was considered. The most non-significant covariate would be excluded from model and so on. The 3rd to 10th model were modeled by using *backward method*. The 4th model was the least standard deviation of model, but included many non-significant covariates. The 10th model was contained the minimum covariates, and the standard deviation was slightly different from other models. Then the final model by using *enter method* was the 10th model.

*PONDERAL = 29.390 –0.521*VISITMONTH +0.250*HILLTRIBE +0.554*CHILDORDER -1.171*HIVMOMPOS*

Next the models by using *forward method* were compared. According to the results of univariate GEE analysis in Table 4.15, there was eleven time-independent covariates that were significant associated with outcome variable PONDERAL among lowland or hilltribe children. By descending significant, there were PREGORDER, CHILDORDER, HIVMOMPOS, AGEMOM, BHEAD, FEMALE, BPONDERAL, GESTATION, CHILDNO, DELIVER1, and DELIVER2, respectively. The most significant associated with outcome variable PONDERAL would be the first covariate considered in the multivariate model. If the model was fitted, next order of covariate would be considered, and so on. The process was stopped when model was not fitted or some covariate did not significant associated with PONDERAL. Then the multivariate GEE model of outcome variable "PONDERAL" by using *forward method* was shown in Table 4.31.

There were three models using *forward method* were compared, all models are fitted. The 11th model was the initial model, in this only the most significant covariate in univariate analysis, PREGORDER was included. In the 12th model, covariates PREGORDER and CHILDORDER were added, but AGEMOM was not significant associated with PONDERAL. After that the process was stopped. When the standard deviation of the model was considered, the least standard deviation of model was the 12th model, but all of covariates were not significant. Thus the final model for *forward method* was the 11th model.

*PONDERAL= 29.672 -0.530*VISITMONTH +0.228*HILLTRIBE +0.413*PREGORDER*

Table 4.31 Results from the Multivariate GEE Analysis of Ponderal Index among Lowland and Hilltribe Children Using *Forward Method*

Variables	Model			
	11th	p	12th	p
Intercept	29.672	<0.001**	29.349	<0.001**
VISITMONTH	-0.530	<0.001**	-0.520	<0.001**
HILLTRIBE	0.228	0.479	0.334	0.338
FEMALE				
GESTATION				
BPONDERAL				
BHEAD				
PREGORDER	0.413	<0.001**	0.104	0.768
CHILDORDER			0.426	0.270
CHILDNO				
DELIVER1				
DELIVER2				
AGEMOM				
HIVMOMPOS				
Number of Observations	847		768	
Wald χ^2 for model fitting	1,199	<0.001**	1,217	<0.001**
Scale Parameter	27.614		24.639	
Standard Deviation of the Model	762.519		607.078	

** Significant level at 0.05.

Between three methods; *enter, backward and forward method* would gave difference final model as showed in Table 4.32

Table 4.32 Final Model from the Multivariate GEE Analysis of Ponderal Index among Lowland and Hilltribe Children, Three Methods Comparison

Variables	Model					
	Enter	p	Backward	p	Forward	p
Intercept	30.407	<0.001**	29.390	<0.001**	29.672	<0.001**
VISITMONTH	-0.526	<0.001**	-0.521	<0.001**	-0.530	<0.001**
HILLTRIBE	0.429	0.160	0.250	0.481	0.228	0.479
FEMALE						
GESTATION						
BPONDERAL						
BHEAD						
PREGORDER					0.413	<0.001**
CHILDORDER			0.554	0.001**		
CHILDNO						
DELIVER1						
DELIVER2						
AGEMOM						
HIVMOMPOS	-1.138	0.029**	-1.171	0.022		
Number of Observations	861		762		847	
Wald χ^2 for model fitting	1,176	<0.001**	1,207	<0.001**	1,199	<0.001**
Scale Parameter	27.846		24.662		27.614	
Standard Deviation of the Model	775.396		608.222		762.519	
F_{it}	–[†]		–[†]		–[†]	

** Significant level at 0.05.
[†]Unavailable because variance of the model more than variance of the outcome variable.

All models from difference methods were fitted, but difference method was gave the different model. The model using *enter method* was included only time-independent covariate HIVMOMPOS. Whereas, the model using *backward method* was included time-independent covariates; CHILDORDER and HIVMOMPOS. The model using *forward method* was included only PREGORDER. The standard deviation of model using *backward method* was the least, then model using *backward method* was a final model to predict outcome variable "PONDERAL".

In conclusion, from Table 4.32 there were not significant different among lowland and hilltribe children (β=0.250, p=0.481). Ponderal index was significant negative associated with visit months (β=-0.521, p<0.001). If age of children was considered as visit months, then ponderal index was decreased when a child was grew up. However, the factors affected to ponderal index of children were only children order and maternal HIV status. Children order was significant positive associated with ponderal index (β=0.554, p=0.001). Children who were born to HIV infected mother, were had ponderal index significant lower than children who were born to HIV uninfected mother (β=-1.171, p=0.022). From these results, the GEE model that would explain the growth pattern by using head circumference for age as a growth indices as following.

Lowland children;

*PONDERAL = 29.390 –0.521*VISITMONTH +0.554*CHILDORDER - 1.171*HIVMOMPOS*

Hilltribe children;

*PONDERAL = 29.640 –0.521*VISITMONTH +0.554*CHILDORDER - 1.171*HIVMOMPOS*

The pattern of predict ponderal index of lowland and hilltribe children, when children order and maternal HIV status were controlled, were shown in Figure 4.15. The ponderal index in hilltribe children will be higher than lowland. However, the patterns of change among both groups will similar. The ponderal index will stable decreasing along the time of age.

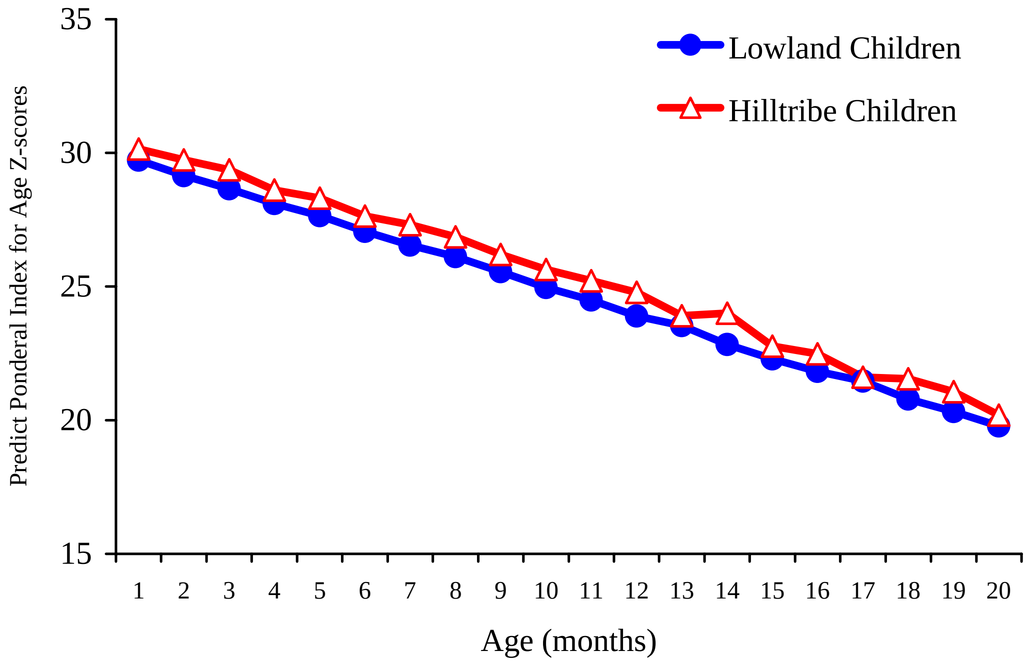

Figure 4.15 Predict Ponderal Index of Lowland and Hilltribe Children

4.7.5 Overall Growth Index

Multivariate GEE models of outcome variable "ALLGROWTH" by using *enter method* were shown in Table 4.33.

When two models using *enter method* were compared, all model were fitted ($p<0.001$). The 1st model was determined the least standard deviation of model, but there were many covariates did not significant associated with ALLGROWTH. In the 2nd model, the number of time-independent covariates was less than the 1st model, but the standard deviation of model was slightly increased. Thus the 2nd model was a final model that used to predict ALLGROWTH using *enter method.*

*ALLGROWTH= 31.862 +0.882*VISITMONTH -0.155*HILLTRIBE – 1.152*FEMALE +1.748*BWKG*

Table 4.33 Results from the Multivariate GEE Analysis of Overall Growth Index among Lowland and Hilltribe Children Using *Enter Method*

Variables	Model			
	1st	p	2nd	p
Intercept	21.970	<0.001**	31.862	<0.001**
VISITMONTH	0.881	<0.001**	0.882	<0.001**
HILLTRIBE	-0.058	0.779	-0.155	0.423
FEMALE	-1.095	<0.001**	-1.152	<0.001**
GESTATION	0.081	0.194		
BWKG	0.969	0.034**	1.748	<0.001**
BLT	0.125	0.180		
BPONDERAL	0.040	0.355		
BHEAD	0.053	0.522		
PREGORDER	-0.091	0.205		
CHILDNO	0.168	0.737		
DELIVER1	0.219	0.300		
DELIVER2	-0.848	0.102		
Number of Observations	246		255	
Wald χ^2 for model fitting	9,791	<0.001**	8,758	<0.001**
Scale Parameter	6.145		6.190	
Standard Deviation of the Model	37.756		38.319	

** Significant level at 0.05.

Multivariate GEE models of outcome variable "ALLGROWTH" by using *backward method* were shown in Table 4.34.

Firstly, the 1st model was modeled by using *enter method*, included only significant covariates with ALLGROWTH in univariate analysis were considered. The most non-significant covariate would be excluded from model and so on. The 3rd and 4th model were modeled by using *backward method*. The 3rd model was the least standard deviation of model (37.758). When one covariate was removed from the model, the standard deviation of the model was slightly increased. In the 7th model, the number of covariates was minimized and all of covariates were significant associated with ALLGROWTH. In addition, the standard deviation of the 7th model (38.227) did not different from other models, so the final model by using *enter method* was the 7th model.

*ALLGROWTH= 24.326 +0.881*VISITMONTH – 0.161*HILLTRIBE – 1.111*FEMALE +0.987*BWKG +0.165*BLT +0.062*BHEAD*

Next the models by using *forward method* were compared. According to the results of univariate GEE analysis in Table 4.16, there were ten time-independent covariates that were significant associated with outcome variable HEAD among lowland or hilltribe children. By descending significant, there were FEMALE, BWKG, BHEAD, BLT, CHILDNO, GESTATION, BPONDERAL, DELIVER1, DELIVER2, and PREGORDER, respectively. The most significant associated with outcome variable ALLGROWTH would be the first covariate considered in the multivariate model. If the model was fitted, next order of covariate would be considered, and so on. If the model was not fitted or some covariates were not significant with ALLGROWTH, the process would be stopped. Then the multivariate GEE model of outcome variable "ALLGROWTH" by using *forward method* was shown in Table 4.35.

Table 4.34 Results from the Multivariate GEE Analysis of Overall Growth Index among Lowland and Hilltribe Children Using *Backward Method*

Variables	Model 1st	p	3rd	p	4th	p	5th	p	6th	p	7th	p
Intercept	21.970	<0.001**	22.225	<0.001**	21.691	<0.001**	21.262	<0.001**	24.390	<0.001**	24.326	<0.001**
VISITMONTH	0.881	<0.001**	0.881	<0.001**	0.881	<0.001**	0.880	<0.001**	0.882	<0.001**	0.881	<0.001**
HILLTRIBE	-0.058	0.779	-0.057	0.784	-0.042	0.840	-0.097	0.624	-0.122	0.531	-0.161	0.405
FEMALE	-1.095	<0.001**	-1.096	<0.001**	-1.104	<0.001**	-1.082	<0.001**	-1.116	<0.001**	-1.111	<0.001**
GESTATION	0.081	0.194	0.082	0.194	0.085	0.184	0.084	0.188				
BWKG	0.969	0.034**	0.965	0.035**	0.862	0.050	0.862	0.050	0.957	0.028**	0.987	0.023**
BLT	0.125	0.180	0.124	0.183	0.160	0.022**	0.166	0.018**	0.164	0.019**	0.165	0.016**
BPONDERAL	0.040	0.355	0.040	0.354	0.063	0.001**	0.064	0.001**	0.063	0.001**	0.062	0.001**
BHEAD	0.053	0.522	0.052	0.533								
PREGORDER	-0.091	0.205	-0.090	0.207	-0.085	0.230						
CHILDNO	0.168	0.737										
DELIVER1	0.219	0.300	0.225	0.283	0.268	0.198	0.276	0.187	0.368	0.091		
DELIVER2	-0.848	0.102	-0.821	0.113	-0.821	0.097	-0.881	0.061	-0.913	0.050		
Number of Observations	246		246		246		247		253		253	
Wald χ^2 for model fitting	9,791	<0.001**	9,499	<0.001**	9,297	<0.001**	9,156	<0.001**	9,273	<0.001**	9,073	<0.001**
Scale Parameter	6.145		6.145		6.149		6.151		6.145		6.183	
Standard Deviation of the Model	37.756		37.758		37.807		37.835		37.759		38.227	

** Significant level at 0.05

There were four models using *forward method* were compared, all models are fitted ($p<0.001$). The 8th model was the initial model, in this only the most significant covariate in univariate analysis, FEMALE was included. In 9th model, covariates FEMALE and BWKG were added, and both were significant associated with ALLGROWTH. Then covariates FEMALE, BWKG, and BHEAD were added in the 10th model, also all of them were significant associated with ALLGROWTH. After that, covariate BLT was added in the 11th model, but this covariate was not significant associated with ALLGROWTH. Then the process was stopped. When the standard deviation of the model was considered, the least standard deviations of model were the 10th, 9th, 8th, and 11th model respectively. The standard deviation of model would decrease when more covariate were added. Whatever, the 10th model was gave the least standard deviation of model, and all of covariates were significant associated with ALLGROWTH. So this model might not be an appropriate model. Thus the final model for *forward method* was the 10th model.

$$ALLGROWTH= 29.496 +0.882*VISITMONTH -0.166*HILLTRIBE - 1.108*FEMALE +1.566*BWKG +0.090*BHEAD$$

Between three methods; *enter, backward and forward* were gave difference final model as showed in Table 4.36.

All models from difference methods were fitted ($p<0.001$). The models using three methods were gave the different models. The time-independent covariates were including in the model using *enter method* were; FEMALE and BWKG. In the model using *backward method* included covariates; FEMALE, BWKG, BLT, and BPONDERAL. While as, FEMALE, BWKG, and BHEAD were included in the model using *forward method*. When the standard deviation of the model was considered, the model using *forward method* was the least. Then the final model to predict outcome variable “ALLGROWTH” could be modeled by using *forward method*.

Table 4.35 Results from the Multivariate GEE Analysis of Overall Growth Index among Lowland and Hilltribe Children Using *Forward Method*

Variables	Model							
	8th	p	9th	p	10th	p	11th	p
Intercept	37.277	<0.001**	31.862	<0.001**	29.496	<0.001**	25.928	<0.001**
VISITMONTH	0.882	<0.001**	0.882	<0.001**	0.882	<0.001**	0.881	<0.001**
HILLTRIBE	-0.110	0.610	-0.155	0.423	-0.166	0.388	-0.198	0.310
FEMALE	-1.243	<0.001**	-1.152	<0.001**	-1.108	<0.001**	-1.083	<0.001**
GESTATION								
BWKG			1.748	<0.001**	1.566	<0.001**	1.298	<0.001**
BLT							0.064	0.076
BPONDERAL								
BHEAD					0.090	0.008**	0.125	0.003**
PREGORDER								
CHILDNO								
DELIVER1								
DELIVER2								
Number of Observations	257		255		255		253	
Wald χ^2 for model fitting	8,746	<0.001**	8,759	<0.001**	9,340	<0.001**	8,816	<0.001**
Scale Parameter	6.611		6.190		6.160		6.167	
Standard deviation of the model	43.699		38.319		37.941		38.030	

** Significant level at 0.05.

Table 4.36 Final Model from the Multivariate GEE Analysis of Overall Growth Index, Three Methods Comparison

Variables	Model					
	Enter	p	Backward	p	Forward	p
Intercept	31.862	<0.001**	24.326	<0.001**	29.496	<0.001**
VISITMONTH	0.882	<0.001**	0.881	<0.001**	0.882	<0.001**
HILLTRIBE	-0.155	0.423	-0.161	0.405	-0.166	0.388
FEMALE	-1.152	<0.001**	-1.111	<0.001**	-1.108	<0.001**
GESTATION						
BWKG	1.748	<0.001**	0.987	0.023**	1.566	<0.001**
BLT			0.165	0.016**		
BPONDERAL			0.062	0.001**		
BHEAD					0.090	0.008**
PREGORDER						
CHILDNO						
DELIVER1						
DELIVER2						
Number of Observations	255		253		255	
Wald χ^2 for model fitting	8,758	<0.001**	9,073	<0.001**	9,340	<0.001**
Scale Parameter	6.190		6.183		6.160	
Standard Deviation of the Model	38.319		38.227		37.941	
F_{it}	–[†]		–[†]		–[†]	

** Significant level at 0.05.
[†]Unavailable because variance of the model more than variance of the outcome variable.

In conclusion, from Table 4.36 there were not significant different among lowland and hilltribe children (β=-0.166, p =0.388). Nevertheless, overall growth index was significant positive associated with visit months (β=0.882, p<0.001). If age of children was considered as visit months, it was means that overall growth index was increased along the time when a child was grew up. However, the factors affected to overall growth index in children were neonatal gender, birth weight, and birth head circumference. Female children were significant increase over time of weight less than male (β=-1.108, p<0.001). In contrast, birth weight and birth head circumference were significant positive associated with overall growth index (β=1.566, p<0.001 and β=0.090, p=0.008 repectively). From these results, the GEE model that would explain the growth pattern by using overall growth index as a growth indices as following.

Lowland children;

*ALLGROWTH= 29.496 +0.882*VISITMONTH -1.108*FEMALE +1.566*BWKG +0.090*BHEAD*

Hilltribe children;

*ALLGROWTH= 29.330 +0.882*VISITMONTH -1.108*FEMALE +1.566*BWKG +0.090*BHEAD*

In addition, Figure 4.16 showed pattern for predict overall growth index of lowland and hilltribe children, when neonatal gender, birth weight, and birth head circumference were contolled. The graphs showed that predict overall growth index of both groups will almost similar. After birth, the overall growth index of children will increasing along with age, and this change will be stable.

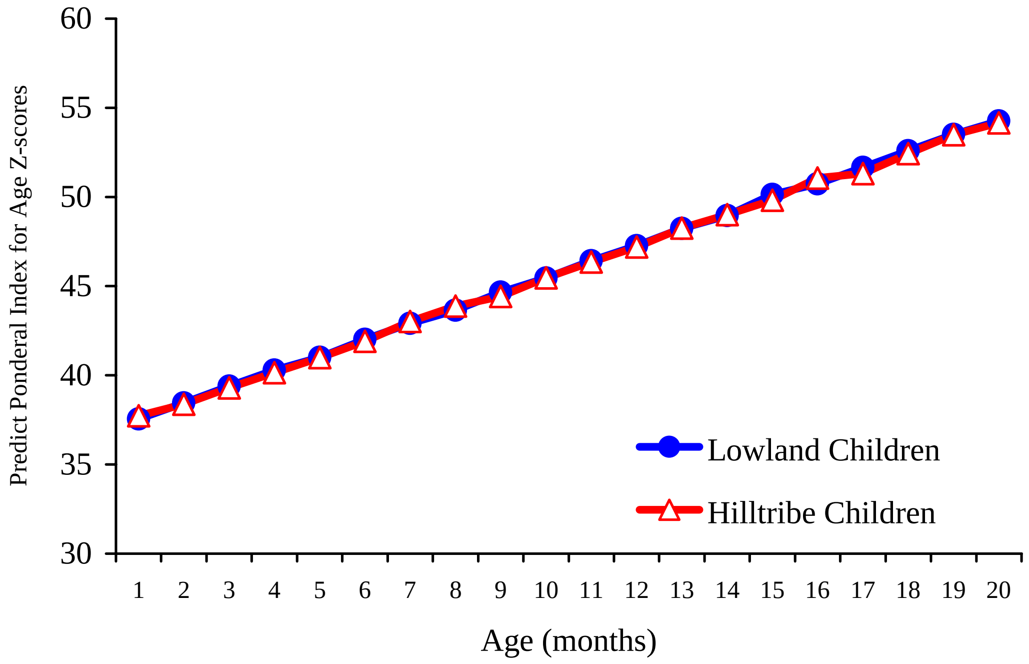

Figure 4.16 Predict Overall Growth Index of Lowland and Hilltribe Children

CHAPTER V
DISCUSSION

In this study, the discussion will be illustrated as following.

5.1. Data Collection

The study population was birth cohort in Mae Chan Hospital defines as children who were born between January 1, 2001 to December 31, 2004, and their mothers were resided in Mae Chan District, Chiang Rai Province. The follow-up periods started from July 1, 2002 to June 30, 2006. Because this study was a longitudinal retrospective cohort study, the data was collected during the last seven years. Practically, data were collected from delivery registrations and OPD cards, many data were disappeared, especially immunization data. In case of children who lived in other sub-districts, data were collected from health centers, but information related to children growth was unavailable. And data were also collected from mothers and children health hand books, but children growth data were not completed. And some mothers did not keep that book, so the information was lost. In some children, we could not found them in identification address. Probably they did not inform their registration address, but they informed only current address.

Missing data is one of the most problems in longitudinal data analysis. If only a few data points are missing from large data sets, the problems are less serious and almost some procedure for handling missing values yields similar results. However, if a lot of data are missing from a small to moderately sized data set, the problems can be very serious. Unfortunately, there are as yet no firm guidelines for how much missing data can be tolerated for a sample of a given size (Tabachnick, 2001). Missing values arise in an analysis of longitudinal data whenever one or more of the sequences of measurements from subjects within the study are incomplete, such as intended measurements are not taken, are incomplete, or are otherwise unavailable. The missing value of covariates and outcome variables were shown in Table 5.1 and 5.2 respectively. Almost of the covariates were contained missing data in a low percentage of all data, excepted ethnicity and gender, as showed in Table 5.1. Children order, birth spacing, and ANC visits were the most missing values respectively. Most regression programs deal with missing values by excluding all records with missing values in any of the covariates. Ignoring missing data by using a complete case analysis can produce biased results. Therefore, these can result in the discarding of substantial amounts of information and a considerable loss of power. However, this dataset was contained missing values in covariates. These may effect to decrease the sample size in analysis and also loss of power of the test.

Table 5.1 Missing Data of Covariates (Number of Subjects = 1,028).

Covariates	Percentage of Missing Data
Ethnicity	0
Gender	0
Gestational Age	5.16
Birth Weight	1.75
Birth Length	1.46
Ponderal Index at Birth	2.14
Birth Head Circumference	1.07
Pregnancy Order	2.24
Children Order	11.09
Birth Spacing, if Pregnancy Order > 1	10.88
Number of Children at Deliver	0.10
Maternal Age at Pregnancy	0.49
Maternal HIV Status	1.07
Maternal Hematocrit	0.19
Antenatal Care (ANC) Visits	7.78

Table 5.2 showed percentage of incomplete data of five outcome variables considered from five times follow up of immunization schedule at 2, 4, 6, 9, and 18 month of age. Most subjects contained incomplete follow-up data in each outcome variables, head circumference for age and overall growth index were the most. The missing data of repeated measurements outcome variable in longitudinal study were

occurred as drop-outs or intermittent missing data. When subjects have missing data at the end of a study, they are defined as drop-outs. In the other hand, subjects miss one particular measurement, and then return to the study at the next follow-up, this type of missing is defined as intermittent missing data (Twisk, 2003). In practice, drop-outs and intermittent missing data usually occur together. Unfortunately, both types of missing data occurred in these datasets. When GEE analysis is performed on an incomplete dataset with informative missing data, the calculation of the working correlation structure is biased, and therefore the calculation of the regression coefficients is also biased. Then the growth pattern in all growth indices were gave inappropriate results.

Table 5.2 Percentage of Incomplete Data of Outcome Variables Considered from Five Times Follow Up of Immunization Schedule at 2, 4, 6, 9, and 18 Month of Age (Number of Subjects = 1,028).

Outcome Variables	Percentage of incomplete follow up
Weight for Age	77.50
Length for Age	85.91
Head Circumference for Age	91.88
Ponderal Index	86.40
Overall Growth Index	91.88

However, in this analysis the month of age was included as 1, 2, 3, …, 19. Missing data in each month of follow-up was so much especially during 11-16 months, which did not necessary for immunization schedule. Therefore, the growth during that period may not be able to describe appropriately.

5.2. Sample Size

According to sample size calculation Twisk J.W.R. (2003: 281) derived in equation (3.1) as following.

$$N = \frac{\left(Z_{(1-\alpha/2)} + Z_{(1-\beta)}\right)^2 \sigma^2 (r+1)\left[1+(T-1)\rho\right]}{v^2 rT}$$

where N is the sample size in both of hilltribe and lowland groups, r is the ratio between the control (lowland) size and the study (hilltribe) size, $Z_{(1-\alpha/2)}$ is the $(1-\alpha/2)\times 100\%$ percentile point of the standard normal distribution, $Z_{(1-\beta)}$ is the $(1-\beta)\times 100\%$ percentile point of the standard normal distribution, σ is the standard deviation of the outcome variable, T is the number of follow-up measurements, ρ is the correlation coefficient of the repeated measurements, and v is the difference in mean value of the outcome variable between two groups.

The actual sample size in this study, total 1,028 children was included 715 lowland and 313 hilltribe children. According to repeated measurement of outcome variables in every visit months of immunization, many subjects selectively miss their visits or return at non-scheduled points in time. As a result, the measurement times were irregular, yielding a highly imbalanced data structure. In addition, the frequency and timing of the visits might be correlated with the longitudinal outcomes. Then the visit months would be calculated from the difference between birth date and visit date, coded as 1, 2, 3, …, 19 months. There were 19 times of follow up, which included all of measures during aged less than and equal 18 months. From the sample sizes that we could include in this study, were used for power of the test consideration. The power of the test is the probability that the test will find a statistically significant difference between lowland and hilltribe children, as a function of the size of the true difference between those two populations. The power of the test is defined as $(1-\beta)$. Then, the power of the tests was considered from each outcome variables; weight for age, length for age, head circumference for age, ponderal index, and overall growth index as showed in Table 5.3.

From Table 5.3, power of the tests were calculated from N, r, T, σ, ρ, and v that all considered from exactly data in this study and demonstrated in each outcome variables. The power of test for the differences between lowland and hilltribe children in weight for age, length for age, head circumference for age, ponderal index, and overall growth index were approximately 89, 94, 74, 38, and 87 percent respectively. From the study methodology, the sample sizes were calculated from pilot study data, values of r, T, σ, ρ, and v were different from the real data collection. However, we expected the power of test should be 80 percent, then the power of the test regarding to sample sizes of head circumference and ponderal index were inadequate. We would need a much larger sample size in order to reduce the confidence interval of our estimate to a range that is acceptable for our purposes.

Table 5.3 Power of the Tests Calculation from Actual Sample Size of the Repeated Measurements from Five Continuous Outcome Variables Comparison between Two Groups of Children Statistically Significant on a 5%.

Outcome Variables	N	r	σ	ρ ‡	v	Power of the Tests
Weight for Age	1,028	2	1.44	0.52	-0.03	89%
Length for Age	676	3	1.43	0.39	0.02	94%
Head Circumference for Age	230	2	1.33	0.47	-0.10	74%
Ponderal Index	672	3	6.19	0.23	-0.33	38%
Overall Growth Index	229	2	6.05	0.20	0.19	87%

‡Correlation coefficient of repeated measurements was estimated from the GEE method with exchangeable correlation structure.

5.3. Statistical Analysis

In this study, the outcome variables were continuous variables containing the weight for age, length for age, head circumference for age, ponderal index and overall growth index. The data were measured repeatedly through time and were not independent. This longitudinal data was collected retrospectively by extracting multiple measurements on each person from historical record. In addition, the spaced time intervals for each measure were not equal. Missing data in all outcome variables and independent variables were occurred. Generally, longitudinal stability of the variables of interest was analyzed using GEE by regression of the initial value to the values for all later measurements. This method results in one standardized regression coefficient, which could be interpreted as a longitudinal correlation coefficient. GEE took into account that repeated measurements on the same subject were not independent. However, there were other methods for longitudinal data analysis, e.g. random coefficient analysis and repeated measures multivariate analysis of variance.

Random coefficient analysis is also known as multilevel analysis or mixed effect analysis, which was initially developed in the social sciences and more specifically for educational research. In longitudinal studies, the simplest form of random coefficient analysis is an analysis with only a random intercept. The corresponding statistical model analyses a longitudinal relationship between an outcome variable and time (Twisk, 2003). The repeated measures are the use of two or more responses from a single individual in an analysis of variance (ANOVA) or multivariate analysis of variance (MANOVA). The purpose of a repeated measures design is to control for individual-level differences that may affect the within-group variance (Hair, 1998). The repeated measures procedure performs an analysis of variance on within-subject designs using the general linear models approach. One of the advantages (if both GEE analysis and random coefficient analysis were compared), both will be availably performed on the datasets with missing data, although both differ in the way to treat missing data. Whereas, repeated measures MANOVA only the subjects with complete data are included in the analysis (Twisk, 2003). Additionally, other advantages of analysis with GEE were that time points did not have to be distributed evenly, and it copes with missing observations by using all available data. Because time is one of the predictor variables in the model used to analyse the relationships between repeated measures outcome variables and several covariates. When the repeated measurements were equally spaced a non-significant result was found, while when the repeated measurements were unequally spaced a highly significant relationship was observed. These differences emphasize the important of adding an actual time variable to the statistical model, especially when the time intervals are unequally spaced. Either equally or unequally spaced time intervals could be used in GEE. In conclusion, GEE method was appropriated for this study.

5.4. Correlation Structure of GEE Model

With GEE the relationships between the variables of the model at different time-points are analysed simultaneously. Because the repeated observations within one subject are not independent of each other, a correlation must be made for these within-subject correlations. There are various correlation structures can be use depend on correlations between subsequent measurements (Twisk, 2003). Subsequently, in this study various correlation structures were compared for weight for age, length for age, head circumference for age, ponderal index, and overall growth index. The four correlation structures were compared, e.g. exchangeable, first order autocorrelation, second order autocorrelation, and stationary. The results concluded that the exchangeable correlation structure was the most appropriate for this dataset, because gave the least standard deviation of model and the least standard error of coefficient. However, we also found that the second autoregressive correlation structure gave the least standard deviation of the GEE model of weight for age. From data reviewing, weight for age was increased during first few months of age. Then it was decreased until the beginning of the second year of life, and was increased again after that. This pattern plot style was also found in length for age and head circumference for age. Whereas, ponderal index and overall growth index were gave different pattern plot. The correlation structures of different growth indices should be different depend on outcome variables or length of measurement time. Unfortunately, there is no straightforward way to determine which correlation structure should be used.

Therefore, we could not know that the GEE model with exchangeable correlation structure was the best method for analysis of this dataset.

5.5. Factors of Growth Pattern among Lowland and Hilltribe Children

The first objective of this study was to construct GEE model for growth pattern of hilltribe and lowland children who were born at the Mae Chan Hospital. GEE model was constructed as showed in the Chapter Four. Then the second objective was to describe growth pattern and to identify the factors affecting on growth of both group of children. Thus, this part concern with the discussion related to growth pattern and factors effect to growth of hilltribe and lowland children. To our knowledge, there is no previous study that has examined the growth pattern and factors effect to growth among lowland and hilltribe children. The final GEE models of five growth indices; weight for age, length for age, head circumference for age, ponderal index, and overall growth index were shown in Table 5.4.

5.5.1. Weight for Age

Since the final multivariate GEE model of weight for age with an exchangeable correlation structure was constructed by using *backward method* (Table 5.4), which showed growth pattern of weight for age among lowland and hilltribe children. Weight for age of hilltribe children was slightly higher than lowland children but was not significant difference. We considered the age of children by using visit months, and found the significant negative association between age of children and weight for age. When age of children was increased, weight for age was significant decreased. In addition, the factors affected to weight for age were birth weight, birth length, birth head circumference, and pregnancy order. The heavier, higher, or larger head circumference children would have weight for age more than the others. This result was similar to some previous studies (Baird, 2005; Cole, 2004; Ong, 2004), that showed the association between high birth weight and overweight and obesity in children, adolescents, and adults. While, the child who was born to mother with several pregnancy times would be decreased weight for age less than who was born to first pregnant mother, likewise, some study related with growth pattern of children (Diamond, 2001).

In our study neonatal gender did not associate with weight for age, likewise, from Christensen' study (Christensen, 2006) found that no consistent differences in postnatal weight pattern were observed between male and female neonates. However, there were other factors, parental size (Pietiläinen, 2001) or neonatal HIV status, were associated with weight in another study. For instance, neonatal HIV status, showed that the odds of falling below -2.00 z-scores by 20 months for length and weight for HIV-infected children born to HIV-infected mother compared to uninfected children born to HIV-infected mother were 2.10, and 2.84 respectively. They concluded that anti-retroviral therapy was unavailable HIV-infected children aged 0-18 months suffer significant stunting, undernutrition, and wasting compared to uninfected children (Bailey, 1999). The differences of weight and length between HIV-infected and uninfected children born to HIV-infected mother increased with age ($p<0.001$). Uninfected children were significantly taller and heavier from very early ages, and by 10 years of age, they were estimated to be almost 7 kg (22%) heavier and 7.5 cm (5.6%) taller than infected children (The European Collaborative Study, 2003). Unfortunately, this factor did not available in out study.

5.5.2. Length for Age

The multivariate GEE model of length for age with an exchangeable correlation structure of length for age which constructed by using *enter, backward,* or *forward method* were gave the same final model, this model was showed in Table 5.4. Length for age of hilltribe children was lower than lowland children, but the different was not significant. Visit months would indicate the children's age, the length for age was increased when the children got more age. Further, the factors affected to length for age were birth weight, and pregnancy order. The heavy children at birth would be increased length for age more than light children, similarly with study of Gigante (2006). Inversely, some study (Fewtrell, 2001) suggested that infants who were longer and thinner at birth showed greater postnatal growth. While, the child who was born to mother with several pregnancy times would be decreased length for age less than who was born to first pregnant mother.

In general, male children would be increase length more than female children, especially in adolescent (Lowrey, 1978). Likewise, Morris (1998) mentioned that length was found to vary significantly by sex. Although in our study was not found the different of length for age among male and female children. Nevertheless, parental size or neonatal HIV status, which was not available in our study, might be affect to length as showed in some studies (Pietiläinen, 2001; Bailey, 1999; The European Collaborative Study, 2003). The result from other studies showed that birth length was associated with length in later age, for every centimeter in birth length, adolescent length increased 0.9 cm and for every kilogram at birth, adolescent length increased 4 cm, and body mass index increased 0.5 kg/m^2 (Pietiläinen, 2001). Further, family size and birth order in higher socio-economic status group did not correlated with future height, perhaps due to small differences within this group. On the other hand, maternal height correlated with future height (Diamond, 2001). When mother visited to ANC more often, neonatal length would be increase. But, there was no study showed association between number of ANC visits and length for later age. Normally, ANC visit was expected to help identify high-risk pregnancies and it is likely that this leads to an increase in institutional deliveries. ANC visits were help for identify delivery-related (Mishra, 2002). Probably, ANC visits were indirect effect for children growth, mother would get education during ANC visits.

5.5.3. Head Circumference for Age

From the final multivariate GEE model of head circumference for age with an exchangeable correlation structure constructed by using *forward method* in Table 5.4, which showed that there were not different in head circumference for age between lowland and hilltribe children. The head circumference for age decreased when the children grow up. In addition, the factors affected to head circumference for age were birth weight, birth head circumference, and delivery method. The heavy or large head circumference child would be increased head circumference for age more than light child. These results were consistent with some study (Illingworth, 1980; Samuelsen, 2004). The child who was delivered by cesarean section would be increased head circumference for age more than who was normally delivered.

The ponderal index at birth did not associate with head circumference for age in our study, however, this covariate showed a significant negative association with gains in weight, length, and occipitofrontal head circumference between birth and 18 months, suggesting that infants who were longer and thinner at birth showed greater postnatal growth (Fewtrell, 2001).

5.5.4. Ponderal Index

The final multivariate GEE model of ponderal index with an exchangeable correlation structure constructed by using *backward method* (Table 5.1) showed that the ponderal index among lowland and hilltribe children was not different. The ponderal index would decrease when the children grow up. We also found that the factors affected to ponderal index were children order and maternal HIV status. The children who were not the first child would have the ponderal index more than the first child. Whereas, children who were born to HIV infected mother would have the ponderal index less than who were born to HIV uninfected mother. This result consistent with the study of Bailey (1999) that showed weight and length in children who were born to HIV infected mother significant less than who were born to HIV uninfected mother.

However, short birth spacing was sufficient to increase the opportunity for low birth weight. For the reason that short intervals may not give women adequate time to build up nutritional reserves and a result is infant of low birth weight (Gribble, 1993: 133-146). For this reason, birth spacing might be affect to ponderal index at later age, which our study could not be able to reveal these findings. Gestational age and low birth weight in the other studies were negative associated with ponderal index at later age because prematurity or born before 37 weeks of gestation was the cause of low birth weight (Pojda, 2000).

5.5.5. Overall Growth Index

According to the final multivariate GEE model of overall growth index with an exchangeable correlation structure constructed by using *forward method* (Table 5.1) showed that the overall growth index would increase when the children grow up, these results differ from other growth indices in this study. Otherwise, there were not significant different in overall growth index among hilltribe and lowland children. The other factors that affected overall growth index were neonatal gender, birth weight, and birth head circumference. Regularly, the growth indices, e.g. body mass index or ponderal index were calculated from birth weight and birth length, either was used for indicated overweight or obese in later life. It seems that no study use the growth index combined from birth weight, birth length, and birth circumference. Then a lower overall growth index indicated a longer, thinner infant, while a higher overall growth index indicated a shorter and/or fatter infant. This description was also the same as ponderal index (Clausen, 1997: 23-31). In our study found that female children had overall growth index less than male. Otherwise, birth weight, and birth head circumference were positive associated with overall growth index.

Table 5.4 The Final GEE Models for Growth Pattern of Lowland and Hilltribe Children for Five Growth Indices

Variables	GEE Final Model of Outcome Variables									
	Weight for Age		Length for Age		Head Circumference for Age		Ponderal Index		Overall Growth Index	
	Beta	p	Beta	p	Beta	p	Beta	p	Beta	p
Intercept	-3.754	<0.001**	-1.073	<0.001**	-3.519	<0.001**	29.390	<0.001**	29.496	<0.001**
VISITMONTH	-0.093	<0.001**	-0.056	<0.001**	-0.096	<0.001**	-0.521	<0.001**	0.882	<0.001**
HILLTRIBE	0.041	0.580	-0.050	0.609	0.110	0.398	0.250	0.481	-0.166	0.388
FEMALE									-1.108	<0.001**
GESTATION										
PRETERM										
BWKG	0.957	<0.001**	0.851	<0.001**	0.677	<0.001**			1.566	<0.001**
LOWBW										
BLT	0.026	0.037**								
BPONDERAL										
BHEAD	0.031	0.027**			0.087	0.002**			0.090	0.008**
PREGORDER	-0.052	0.048**	-0.150	<0.001**						
MULTIPREG										
CHILDORDER							0.554	0.001**		
PARITY										
BIRTHSPACE										
CHILDNO										
DELIVER1					0.325	0.012**				
DELIVER2					0.363	0.348				
AGEMOM										
AGEMOM1										
AGEMOM2										
AGEMOM3										
HIVMOMPOS							-1.171	0.022**		
HCT										
ANCTIME										

** Significant level at 0.05.

5.6. Limitation of This Study

The data were longitudinally collected from retrospective cohort of lowland and hilltribe children. Recruitment period was during January 1, 2001 to December 31, 2004, and follow up period started from July 1, 2002 to June 30, 2006. Every child was followed repeatedly through 18-month. The data was collected seven years ago. The secondary data were collected from Mae Chan District hospital and health centers in Mae Chan District. The resources of data were OPD cards, delivery records, hospitalization records, and maternal and child health hand books. Practically, different physicians and nurses records were main information of this resource. Some information might be incomplete and missing that affected to the result of this study. In addition, lack of some important variables that might affect to growth in childhood such as type of feeding (breast milk or formula milk) in the first year of life, parental stature, parental socioeconomic status (e.g. education, occupation, income), nurturing environment, adequate nutrition, maternal psychology and health status during pregnancy, absence of chronic disease or special health care needs. Especially feeding practices during the first year of life also have an important influence on the nutritional status, growth and function of the young child.

CHAPTER VI
CONCLUSION

In this study, the conclusion will be illustrated as following.

6.1. Conclusion

The growth patterns of children aged under 18 months who were born at the Mae Chan Hospital and their mothers resided in Mae Chan District, Chiang Rai Province, Thailand were studied. Maternal ethnicity was used to be a classification of children; lowland and hilltribe. These longitudinal retrospective cohort study started recruitment period since January 1, 2001 to December 31, 2004, and follow up period start from July 1, 2002 to June 30, 2006. Weight for age, length for age, head circumference for age, ponderal index, and overall growth index were used for growth indices. The overall growth index was the new growth indicator that conducted by the combination of birth weight, birth length, and birth head circumference. Time variable was the visit month to immunization schedule. Time-independent covariates were defined from maternal and neonatal factors. Maternal factors were age at pregnancy, HIV status, pregnancy order, birth order, birth spacing, delivery method, number of children at delivery, hematocrit at delivery, and ANC visits. And neonatal factors were gender, gestational age, birth weight, birth length, birth circumference, and ponderal index at birth. GEE models for growth pattern among lowland and hilltribe children were constructed. The univariate GEE analysis was used for determination the factors associated with outcome variables. Three methods of regression were used for model selection in multivariate GEE analysis.

The results showed that the growth among lowland and hilltribe children is slightly different, however, is not significant for all of growth indices.

Factors affected to weight for age are birth weight, birth length, birth head circumference, and pregnancy order. When children are grow up, weight for age is significantly decrease after adjusted for birth weight, birth length, birth head circumference, and pregnancy order. Weight, length, and head circumference at birth are significantly positive associate with weight for age. In contrast, pregnancy order is significantly negative associate with weight for age.

Whereas birth weight, and pregnancy order are effected on length for age. After adjusted for these covariates, height for age is significantly decrease along the times. Birth weight is significantly positive associate with height for age. In the other hand, pregnancy order is significantly negative associate with height for age.

Factors affected to head circumference for age are birth weight, birth head circumference, and delivery method. Head circumference for age is significantly decrease when children grow up with similar to birth weight, birth head circumference, and delivery method. Birth weight and birth circumference are significantly positive associate with head circumference for age. In addition, cesarean section is significantly increase head circumference for age more than normal delivery.

Factors affected to ponderal index changing are children order and maternal HIV status. Ponderal index is significantly increase when children grow up after adjusted for children order and maternal HIV status. Children order is significantly positive associate with ponderal index. HIV-infected mother is significantly decrease ponderal index more than HIV-uninfected mother.

Finally, gender, birth weight, and birth head circumference affect to overall growth index. Overall growth index is significantly increase when children grow up after adjusted gender, birth weight, and birth head circumference. Being female is significantly decrease overall growth index more than male. Additionally, birth weight, and birth head circumference are significantly positive associate with overall growth index.

In summary, the factors affect to growth that found in this study are gender, birth weight, birth length, birth head circumference, pregnancy order, children order, delivery method, and maternal HIV status. Adversely, ethnicity, gestational age, preterm delivery, ponderal index at birth, birth spacing, number of children at delivery, maternal age at pregnancy, maternal HCT, and ANC visits are not found associate with growth indices in this study.

6.2. Recommendation

Firstly, the pattern plot of mean weight, height, and head circumference by age were considered in Figure 4.5 to Figure 4.10. We found that during the first year of age mean of these measurements among lowland and hilltribe children in Mae Chan District are higher than median of the reference for Thai children. After that the mean is lower than the reference. These phenomenons occur in both male and female among lowland and hilltribe children. Perhaps, there are some factors that affected to the decrease of children growth at that period, therefore these should be studied further. In addition, the study should include the way to remain the growth increasing over than the median of the reference for all age of children.

This study was longitudinal retrospective cohort study and the data was collected from the routine growth monitoring. However, there were other factors, which found in other studies, related to growth in children e.g. factors before birth, type of milk intake (breast or formula milk), food and nutrition intake, length and pre-pregnancy weight of mother, parental size, maternal education and occupation, neonatal HIV status who born to HIV-infected mother, illness or disease, etc. Furthermore, enough rest and adequate exercise are also important for child growth. Sleep patterns vary by age and individual child, but most kids need an average of 10 to 12 hours of sleep per night. Sleep gives growing bodies the rest they need to continue growing properly. Because obesity is a growing problem in children, parents should make sure that their children exercise regularly, as well as receive proper nutrition. Any enjoyable activity such as bicycling, walking, or running that will motivate child to get moving will promote good health and fitness and help child maintain a healthy weight. In further study, the prospective cohort study including all of possible factors that affect to growth in children should be used. The other factors that may affect to child growth should include such as physical status of parents and children, food or nutrition intake, and parental socioeconomic (Diamond, 2001).

The infants in this study were enrolled from the district hospital, and so they may not reflect all babies born in the community. Then all children who reside in Mae Chan District, although they are not born at the Mae Chan Hospital, should be included in further study.

Regularly, growth in children is not constant and is characterized by periods of acceleration occurring at different times but in similar sequences for healthy children. The growth is most rapidly after birth and then slows rapidly. From two year-old until about 11 in girls and 13 in boys the rate continues slowly decelerating, and then the adolescent increase begins (Lowley, 1978). During 18-month aged of life, the children's growth may not differ among different ethnicity. Otherwise, if the follow up time are longer than 18 months, the growth may show clearly difference. These may be appropriate for describe the different between lowland and hilltribe later.

BIBLIOGRAPHY

Adams, N. (2003). “The Tai of the Shan State”. Updated on June 3, 2003. Retrieved from http://www.kidland.org/december4/lff0105.htm [Accessed on November 24, 2006]

Alexander, G.R., Kogan, M., Bader, D., Carlo, W., Allen, M., & Mor, J. (2003). “US birth weight/gestational age-specific neonatal mortality: 1995–1997 rates for Whites, Hispanics, and Blacks”. **Pediatrics**, 111: 61-66. Retrieved from http://www.pediatrics.org/cgi/content/full/111/1/e61

Ananth, C.V., & Platt, R.W. (2004). “Reexamining the effects of gestational age, fetal growth, and maternal smoking on neonatal mortality”. **Bio Medical Central Pregnancy and Childbirth**, 4: 22.

Bailey, R.C., Kamenga, M.C., Nsuami, M.J., Nieburg, P., & St Louis, M.E. (1999). “Growth of children according to maternal and child HIV, immunological and disease characteristics: a prospective cohort study in Kinshasa, Democratic Republic of Congo”. **International Journal of Epidemiology**, 28: 532-540.

Baird, J., Fisher, D., Lucas, P., Kleijnen, J., Roberts, H., & Law, C. (2005). “Being big or growing fast: systematic review of size and growth in infancy and later obesity”. **British Medical Journal**, 331: 929-934.

Ballinger, G.A.(2004). “Using generalized estimating equations for longitudinal data analysis”. **Organizational Research Methods**, 7 (2): 127-150.

Berhane, R., Bagenda, D., Marum, L., Aceng, E., Ndugwa, C., Bosch, R.J., & Olness, K. (1997) . “Growth failure as a prognostic indicator of mortality in pediatric HIV infection”. **Pediatrics**, 100(1): 7-12

Bingley, B.J., Douek, I.F., Rogers, C.A., & Gale, E.A.M. (2000). “Influence of maternal age at delivery and birth order on risk of type 1 diabetes in childhood: prospective population based family study”. **British Medical Journal**, 321: 420-424.

Blair, E.M., Liu, Y., H de Klerk, N., & Lawrence, D.M. (2005). “Optimal fetal growth for the Caucasian singleton and assessment of appropriateness of fetal growth: an analysis of a total population perinatal database”. **Bio Medical Central Pediatrics**, 5:13. Published on 24 May 2005. Retrieved from http://www.biomedcentral.com/1471-2431/5/13

Boon, N., Koppes, L. L. J., Saris, W. H. M., & Mechelen, W. Van. (2005). “The Relation between calcium intake and body composition in a Dutch population: The Amsterdam growth and health longitudinal study”. **American Journal of Epidemiology**, 162(1), 27-32.

Brand, E., Wang, J.G., Herrmann, S.M., & Staessen, J.A. (2003). “An epidemiological study of blood pressure and metabolic phenotypes in relation to the Gbeta3 C825T polymorphism”. **Journal of Hypertension**, 21(4): 729-37.

Breslau, N., Chilcoat, H.D., Susser, E.S., Matte, T., Liang, K.Y., & Peterson, E.L. (2001). “Stability and change in children's intelligence quotient scores: a comparison of two socioeconomically disparate communities”. **American Journal of Epidemiology**, 154(8): 711-7.

Bugg, G.J., Atwal, G.S., & Maresh, M. (2002). “Grandmultiparae in a modern setting”. **An International Journal of Obstetrics and Gynaecology**, 109: 249–253.

Buescher, P.A., & Mittal, M. (2006). “Racial disparities in birth outcomes increase with maternal age: Recent data from North Carolina”. **North Carolina Medical Journal**. 67(1): 16-20.

Busato, A., Steiner, L., Martin, S.W., Shoukri, M.M., & Gaillard, C. (1997). “Calf health in cow-calf herds in Switzerland”. **Preventive Veterinary Medicine**, 30(1): 9-22.

Cardwell, C. R., Carson, D. J., & Patterson, C. C. (2005). “Parental age at delivery, birth order, birth weight and gestational age are associated with the risk of childhood Type 1 diabetes: a UK regional retrospective cohort study”. **Diabetic Medicine**, 22: 200–206.

Carey, V., Zeger, S.L., & Diggle, P. (1993). “Modelling multivariate binary data with alternating logistic regressions”. **Biometrika**, 80(3): 517-526.

Chaudhari, S., Bhalerao, M.R., Vaidya, U., Pandit, A. & Nene, U. (1997). “Growth and Development if Twins Compared with Singletons at Ages One and Four Years”. **Indian Pediatrics**, 34: 1081-1086.

Chidambaranathan, S. (August 2004). "Achieving new height." Retrieved from http://www.chennaionline.com/health/Homoeopathy/2004/07homoeopathy03.asp

Christensen, R.D., Henry, E., Kiehn, T.I., & Street, J.L. (2006). “Pattern of daily weights among low birth weight neonates in the neonatal intensive care unit: data from a multihospital health-care system”. **Journal of Perinatology**, 26, 37–43. Retrieved from www.nature.com/jp

Clausen, J.O., Borch-Johnsen, K., & Pedersen, O. (1997). “Relation between Birth weight and the Insulin Sensitivity Index in a Population Sample of 331 Young, Healthy Caucasians”. **American Journal of Epidemiology**, 146(1): 23-31.

Cole, T.J. (2004). “Modeling Postnatal Exposures and Their Interactions with Birth Size”. **Journal of Nutrition**, 134, 201–204.

Damaphong, N., & Saripan, S. (2004). “Food for newborn until 12 months”. Nutrition Division, Department of Health, Ministry of Public Health, Thailand. Nonthaburi: The War Veterans Organization Printing.

Diamond, G., Zalzberg, J., Inbar, D., Cohen, Z., Laks, Y., Geva, D., Grossman1, T., & Cohen, H.J. (2001). “Birth order, birth weight and later patterns of growth”. **Ambulatory Child Health**, 7: 259–267.

Dressler, W.W., Oths, K.S., & Gravlee, C.C. (2005). “Race and ethnicity in public health research: Models to explain health disparities”. **Annual Review of Anthropology**, 34: 231-52.

Dupont W.D. (2002). “Statistical modeling for biomedical researchers. A simple introduction to the analysis of complex data”. Cambridge, United Kingdom: The University of Cambridge Press.

Eriksson, J.G., Forsén, T., Tuomilehto, J., Osmond, C., & Barker, D.J.P. (2001). “Early growth and coronary heart disease in later life: longitudinal study”. **British Medical Journal**, 322: 949-953.

Fewtrell, M.S., Abbott, R.A., Singhal, A., Stephenson, T., MacFadyen, U.M., Clements, H., & Lucas, A. (2001). "Catch-up growth in small-for-gestational-age term infants: a randomized trial." **American Journal of Clinical Nutrition**, 74: 516–23.

Forse´n, T., Osmond, C., Eriksson, J.G., & Barker, D.J.P (2004). “Growth of girls who later develop coronary heart disease”. **Heart**, 90: 20–24.

Galobardes, B., Lynch, J.W. , & Smith, G.D. (2004). “Childhood socioeconomic circumstances and cause-specific mortality in adulthood: Systematic review and interpretation”. **Epidemiologic Reviews**, 26: 7–21.

Gibson,R.S. (2005). “Principles of Nutritional Assessment, 2nd edition”. New York: Oxford University Press.

Gigante, D.P., Horta, B.L., Lima, R.C., Barros, F.C. & Victora, C.G. (2006). “Early Life Factors Are Determinants of Female Height at Age 19 Years in a Population-Based Birth Cohort (Pelotas, Brazil)”. **Journal Nutrition**, 136: 473–478.

Gribble, J.N. (1993). “Birth intervals, gestational age, and low birth weight: Are the relationships confounded?”. **Population Studies**, 47: 133-146.

Hair, J.F. Jr, Anderson, R.E., Tatham, R.L., & Black, W.C. (1998), “Multivariate data analysis, 5th edition”. New Jersey: Prentice-Hall.

http://dnfe5.nfe.go.th (No date). “Mae Chan district, Chiang Rai province”. Retrieved from http://dnfe5.nfe.go.th/localdata/RNorth/ChiangRai/maechan/cr1.htm [Accessed on November 24, 2006]

Illingworth, R.S. (1980). “The Development of the Infant and Young Child, 7th edition”. New Work: Butler & Tanner.

Jung, S., & Ahn, C. (2003). “Sample size estimation for GEE method for comparing slopes in repeated measurements data”. **Statistics in Medicine**, 22: 1305–1315.

Jung, S., & Ahn, C.W. (2005). “Sample size for a two-group comparison of repeated binary measurements using GEE”. **Statistics in Medicine**, 24: 2583–2596.

Kero, J., Gissier, M., Grönlund, M., Kero, P., Koskinen, P., Hemminki, E., & Isolauri, E. (2002). “Mode of Delivery and Asthma – Is There a Connection?”. **Pediatric Research**, 52(1).

Kleinbaum D.G., & Klein M. (2002). "Logistic regression a self-learning text, 2nd edition". New York: Springer-Verlag.

Kleinbaum D.G. Kupper L.L. & Muller K.E. (1998). "Applied regression analysis and other multivariable methods, 2nd edition, New York": Duxbury Press.

Koeing, M.A., Phillips, J.F., Campbell, O.M., & D'Souza, S. (May 1990). "Birth intervals and childhood mortality in rural Bangladesh". **Demography**, 27(2): 251-265.

Lawlor, D.A., Ebrahim, S., & Smith, G.D. (2002). "Is There a Sex Difference in the Association between Birth Weight and Systolic Blood Pressure in Later Life? Findings from a Meta-Regression Analysis". **American Journal of Epidemiology**, 156: 1100-1104.

Lowrey, G.H. (1987). "Growth & development of children. 7th Edition". Chicago: Year Book Meditcal Publisher.

Mishra, U.S., & Ramanathan, M. (2002). "Delivery-related complications and determinants of caesarean section rates in India". **Health Policy and Planning**, 17(1): 90–98.

Morris, S.S., Victora, C.G., Barros, F.C., Halpern, R., Menezes, A.M.B., Cesar, J.A., Hortaa, B.L., & Tomasia, E. (1998). "Length and ponderal index at birth: associations with mortality, hospitalizations, development and post-natal growth in Brazilian infants". **International Journal of Epidemiology**, 27: 242-247.

Nanda, R. (March 2, 2005). "Hematocrit (HCT)". Retrieved from http://www.drugs.com/enc/hematocrit-hct.html [Accressed on November 24, 2006]

Nutrition Division, Department of Health, Ministry of Public Health, Thailand (1999). "Reference of Weight, Length/height, and Nutritional Indices for Thai Population Aged 1 day-19 years". Nonthaburi: The War Veterans Organization Printing.

Nutrition Division, Department of Health, Ministry of Public Health, Thailand (2004). "Guideline of Weight, Length/height for evaluation child growth standard references in Thailand". Nonthaburi: The War Veterans Organization Printing.

Ong, K.K., Petry, C.J., Barratt, B.J., Ring, S., Cordell, H.J., & Wingate, D.L. (2004). “Maternal-fetal interactions and birth order influence insulin variable number of Tandem Repeats Allele class associations with head size at birth and childhood weight gain”. **Diabetes**, 53: 1128–1133.

Parsons, T.J., Power, C., & Manor, O. (2001). “Fetal and early life growth and body mass index from birth to early adulthood in 1958 British cohort: longitudinal study”. **British Medical Journal**, 323: 1331-1335.

Pietiläinen, K.H., Kaprio, J., Räsänen, M., Winter, T., Rissanen, A., & Rose, R.J. (2001). “Tracking of body size from birth to late adolescence: Contributions of birth length, birth weight, duration of gestation, parents’ body size, and twinship”. **American Journal of Epidemiology**, 154(1), 21-29.

Pojda, J., & Kelley, L. (2000). “Low birthweight”. A report based on the International low birth weight symposium and workshop held on 14-17 June 1999 at the International Centre for Diarrhoeal Disease Research in Dhaka, Bangladesh.

Qu, A., Lindsay, B.G., & Li, B. (2000). “Improving generalized estimating equations using quadratic inference functions”. **Biometrika**, 87(4): 823-836.

Razzell, P., Spence, C., & Vines, K. (2004). “Poverty, birth weight, and infant weight gain in Hertfordshire, 1923–1939”. **International Journal of Epidemiology**, 33: 1228–1233.

Richards, M., Hardy, R., Kuh, D. & Wadsworth, M.E.J. (2001). “Birth weight and cognitive function in the British 1946 birth cohort: longitudinal population based study”. **British Medical Journal**, 322: 199-203.

Salihu, H.M., Kinniburgh, B.A., Aliyu, M.H., Kirby, R.S., & Alexander, G.R. (2004). “Racial Disparity in Stillbirth Among Singleton, Twin, and Triplet Gestations in the United States”. **The American College of Obstetricians and Gynecologists**. 104(4): 734-740.

Samuelsena,b, S.O., Stenea, L.C., & Bakketeigc, L.S. (2004). “Association of head circumference at birth among sibling pairs”. **Paediatric and Perinatal Epidemiology**, 18: 26–32.

Sattar, N., & Greer, I.A. (2002). “Pregnancy complications and maternal cardiovascular risk: Opportunities for intervention and screening?”. **British Medical Journal**, 325: 157-160.

School, T.O., & Reilly, T. (2000) “Anemia, Iron and Pregnancy Outcome”. **The Journal of Nutrition**, 130: 443S-447S.

Sheay, W., Ananth C. V., & Kinzler W. L. (2004). “Perinatal mortality in first- and second-born twins in the United States”. **Obstetrics & Gynecology**, 103(1): 63-70.

Song, J., Barnhart, H.X., & Lyles, R.H. (2004). “A GEE approach for estimating correlation coefficients involving left-censored variables”. **Journal of Data Science**, 2: 245-257.

Syddall, H. E., Sayer, A.A., Simmonds, S. J., Osmond, C., Cox, V., Dennison, E. M., Barker, D. J. P., & Cooper, C. (2005). “Birth weight, infant weight gain, and cause-specific mortality: The Hertfordshire cohort study”. **American Journal of Epidemiology**, 161 (11): 1074–1080.

Tabachnick, B. G. & Fidell, L. S. (2001). “Using multivariate statistics, 4th edition”. MA: A Pearson Education Company.

The European Collaborative Study (2003). “Height, weight, and growth in children born to mothers with HIV-1 infection in Europe”. **Pediatrics**, 111: e52–e60.

The Mirror Foundation (No date). “The Tribes”. Retrieved from http://www.hilltribe.org. [Accessed on November 24, 2006]

Twisk,J.W.R. (2003). “Applied longitudinal data analysis for epidemiology: A practical guide”. England: Cambridge University.

WHO. (1995). “Physical status: The used interpretation of anthropometry in Geneva”.

Winikoff, B. (October 1983). “The effects of birth spacing on child and maternal health”. **Studies in Family Planning**. 14(10): 231-245.

Wright, C.M., Corbett, S.S., & Drewett, R.F. (1996). “Sex differences in weight in infancy and the British 1990 national growth standards”. **British Medical Journal**, 313: 515-514.

www.childinfo.org (May 2006). “Antenatal Care”. Retrieved from http://www.childinfo.org/areas/antenatal/ [Accessed on May 9, 2007] www.fantaproject.org (No date). “Comparison of Anthropometric Data to Reference Standards”. Retrieved from www.fantaproject.org/downloads/pdfs/anthro_6.pdf. [Accessed on May 5, 2007]

www.ichiangrai.com (2005). “Chiangrai People”. Retrieved from http://www.ichiangrai.com/en/content/view/67/102/. [Accessed on November 24, 2006]

www.lanna.com (No date). Retrieved from www.lanna.com. [Accessed on November 24, 2006]

www.se-ed.net (No date). “Yao”, Retrieved from http://www.se-ed.net/watwiwek/hilltribe/Yao.htm#l. [Accessed on November 24, 2006]

www.statelessperson.com (No date). Retrieved from http://www.statelessperson.com/show_lawdet.php?id=99&comm=det. [Accessed on November 24, 2006]

www.ywam.no (No date). Retrieved from http://www.ywam.no/shan/eng/i_spraak.html. [Accessed on November 24, 2006]

APPENDIX

APPENDIX A
DATA COLLECTION FORM

Code …………………

แบบบันทึกข้อมูลสำหรับเด็กที่คลอดในโรงพยาบาลแม่จัน

<u>ข้อมูลเกี่ยวกับมารดา</u>

อายุ.............ปี

เชื้อชาติ [ ] ไม่มีข้อมูล [ ] ไทย [ ] ชาวเขา เผ่า...

[ ] อื่นๆ ระบุ..

สัญชาติ [ ] ไม่มีข้อมูล [ ] ไทย [ ] อื่นๆ ระบุ..

ศาสนา [ ] ไม่มีข้อมูล [ ] พุทธ [ ] คริสต์ [ ] อิสลาม [ ] ระบุ ....

อาศัยอยู่ใน ตำบล .... อ.แม่จัน จ.เชียงราย

ANC จำนวน ...….. ครั้ง จำนวนเด็กที่คลอด ……..…คน บุตรที่คลอดเป็นคนที่............

ระยะห่างจากการคลอดของการตั้งครรภ์ก่อนหน้านี้.............ปี..............เดือน

HIV วันที่ตรวจ ………………….……

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

VDRL วันที่ตรวจ ………………….……

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

HBsAg วันที่ตรวจ ………………….……

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

อาการผิดปกติที่พบขณะตั้งครรภ์…...

………………………………...

อาการผิดปกติที่พบขณะคลอด…...

………………………………...

<u>ข้อมูลเกี่ยวกับลูก</u>

เพศ [ ] ชาย [ ] หญิง [ ] ไม่มีข้อมูล

วันเดือนปีเกิด...

เชื้อชาติ [ ] ไม่มีข้อมูล [ ] ไทย [ ] ชาวเขา เผ่า..

[ ] อื่นๆ ระบุ..

สัญชาติ [ ] ไม่มีข้อมูล [ ] ไทย [ ] อื่นๆ ระบุ..

ศาสนา [ ] ไม่มีข้อมูล [ ] พุทธ [ ] คริสต์ [ ] อิสลาม [ ] ระบุ ....

น้ำหนักแรกคลอด .... กรัม ความยาวลำตัว ....ซม. ความยาวรอบศีรษะ .... ซม.

คลอดโดยวิธี [ ] ไม่มีข้อมูล [ ] คลอดปกติ [ ] ผ่าท้อง [ ] อื่นๆ (ระบุ)................................……..……................

อายุครรภ์ขณะคลอด .... สัปดาห์ .... วัน Apgar score ขณะ 1 นาที ...…........... 5 นาที ....

HIV(1) วันที่ตรวจ ………………………

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

HIV (2) วันที่ตรวจ ………………………

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

HIV(3) วันที่ตรวจ ………………………

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

VDRL วันที่ตรวจ ………………………

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

HBsAg วันที่ตรวจ ………………………

ผล [ ] ไม่ได้ตรวจ [ ] บวก [ ] ลบ [ ] ไม่ทราบผล [ ] ไม่มีข้อมูล

อาการผิดปกติที่พบขณะตั้งครรภ์…..

…………………………………...

อาการผิดปกติที่พบขณะคลอด…..

…………………………………...

ประวัติการรับวัคซีน

วันเดือนปี	อายุ (ปี/เดือน)	น้ำหนัก (กก.)	ส่วนสูง (ซม.)	รอบศีรษะ (ซม.)	วัคซีน	หมายเหตุ

APPENDIX B
WORKING CORRELATION STRUCTURES
FOR GENERALIZED ESTIMATING EQUATION MODEL

According to GEE method, the relationship between the variables of the model at different time-point are analyzed simultaneously. Because the repeated observations within on subject are not independent of each other, a correlation must be made for these within-subject correlations. Twisk (2003: 62-66) explained that with GEE, this correlation was carried out by assuming a priori a certain working correlation structure for the repeated measurements of the outcome variable. Let ρ_{jk} denote the population correlation coefficient between the j^{th} and k^{th} measurement on the same subject. If all subjects have n-time repeated measurements, the correlations structure for each subject's measurements is showed in square array of correlation coefficients (Dupont, 2002) as the following.

	t_1	t_2	t_3	$\ldots$	t_n
t_1	1	ρ_{12}	ρ_{13}	$\ldots$	ρ_{1n}
t_2	ρ_{21}	1	ρ_{23}	$\ldots$	ρ_{2n}
t_3	ρ_{31}	ρ_{32}	1	$\ldots$	ρ_{3n}
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
t_6	ρ_{n1}	ρ_{n2}	ρ_{n3}	$\ldots$	1

There were many choices between various correlation structures. The results of analysis with different working correlation structures were different and lead to different conclusions. There is a choice between various correlation structures as following.

1. An Independent Correlation Structure

With this structure the correlation between subsequent measurements are assumed to be zero. In fact, this option is counterintuitive because a special technique is being used to correct for the dependency of the observations and this correlation structure assumes independence of the observations. For instance, if $t=6$ then an independent correlation structure is;

	t_1	t_2	t_3	t_4	t_5	t_6
t_1	1	0	0	0	0	0
t_2	0	1	0	0	0	0
t_3	0	0	1	0	0	0
t_4	0	0	0	1	0	0
t_5	0	0	0	0	1	0
t_6	0	0	0	0	0	1

2. An Exchangeable Correlation Structure

In this structure the correlations between subsequent measurements are assumed to be the same, irrespective of the length of the time interval. For instance, if $t=6$ then an exchangeable correlation structure is;

	t_1	t_2	t_3	t_4	t_5	t_6
t_1	1	ρ	ρ	ρ	ρ	ρ
t_2	ρ	1	ρ	ρ	ρ	ρ
t_3	ρ	ρ	1	ρ	ρ	ρ
t_4	ρ	ρ	ρ	1	ρ	ρ
t_5	ρ	ρ	ρ	ρ	1	ρ
t_6	ρ	ρ	ρ	ρ	ρ	1

3. Stationary Correlation Structure

The stationary correlation structure or called *stationary m-dependent structure* assumes that the correlations t measurements apart are equal, the correlations $t+1$ measurements apart are assumed to be equal, and so on for $t=1$ to $t=m$. Correlations more than m measurements apart are assumed to be zero. When, for instance, a *2-dependent correlation structure* is assumed, all correlations one measurement apart are assumed to be the same, all correlations two measurements apart are assumed to be the same, and the correlations more than two measurements apart are assumed to be zero. If t=6 then an independent correlation structure is;

	t_1	t_2	t_3	t_4	t_5	t_6
t_1	1	ρ_1	ρ_2	0	0	0
t_2	ρ_1	1	ρ_1	ρ_2	0	0
t_3	ρ_2	ρ_1	1	ρ_1	ρ_2	0
t_4	0	ρ_2	ρ_1	1	ρ_1	ρ_2
t_5	0	0	ρ_2	ρ_1	1	ρ_1
t_6	0	0	0	ρ_2	ρ_1	1

4. Autoregressive Correlation Structure

The correlations one measurement apart are assumed to be ρ; correlations two measurement apart are assumed to be ρ^2; correlations t measurements apart are assumed to be ρ^t as following.

	t_1	t_2	t_3	t_4	t_5	t_6
t_1	1	ρ^1	ρ^2	ρ^3	ρ^4	ρ^5
t_2	ρ^1	1	ρ^1	ρ^2	ρ^3	ρ^4
t_3	ρ^2	ρ^1	1	ρ^1	ρ^2	ρ^3
t_4	ρ^3	ρ^2	ρ^1	1	ρ^1	ρ^2
t_5	ρ^4	ρ^3	ρ^2	ρ^1	1	ρ^1
t_6	ρ^5	ρ^4	ρ^3	ρ^2	ρ^1	1

5. Unstructured Correlation Structure

This correlation structure is the least restrictive correlation. All correlations are assumed to be different as following.

	t_1	t_2	t_3	t_4	t_5	t_6
t_1	1	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5
t_2	ρ_1	1	ρ_6	ρ_7	ρ_8	ρ_9
t_3	ρ_2	ρ_6	1	ρ_{10}	ρ_{11}	ρ_{12}
t_4	ρ_3	ρ_7	ρ_{10}	1	ρ_{13}	ρ_{14}
t_5	ρ_4	ρ_8	ρ_{11}	ρ_{13}	1	ρ_{15}
t_6	ρ_5	ρ_9	ρ_{12}	ρ_{14}	ρ_{15}	1

When the results of analysis with different working correlation structures are compared, they differ in such a way that they can lead to wrong conclusions about longitudinal relationships between several variables. It is therefore important to realize which correlation structure is most appropriate for the analysis. However, there is no straightforward way to determine which correlation structure shold be used in GEE. One of the possibilities is to analyze the within-subject correlation structure of the observed data to find out which possible structure is the best approximation of the real correlation structure. Additionally, the simplicity of the correlation structure has to be taken into account when choosing a certain working correlation structure. Basically, the best choice is the simplest correlation structure which fits the data well.

APPENDIX C
DESCRIPTIVE ANALYSIS OF BIRTH WEIGHT

Birth weight was obtained from delivery room records and length measured by pediatrician at the time of first visit. Birth weight is a powerful predictor of infant growth and survival. Infants born with a low birth weight begin life immediately disadvantaged and face extremely poor survival rates. In this part, birth weight will describe in three categories; < 2.5, 2.5 to 3.0, and > 3.0 kg, and compare with characteristics of children.

Table 1C. Characteristics among birth weight group of children.

Variables	Birth weight (kg.)						p
	<2.5	(%)	2.5-3.0	(%)	>3.0	(%)	
Gender							**0.001***
Male	25	(4.7)	189	(36.7)	315	(59.6)	
Female	28	(6.0)	216	(46.0)	226	(48.0)	
Ethnicity							**0.155**
Lowland	38	(5.5)	295	(42.4)	363	(52.1)	
Hilltribe	15	(5.0)	110	(36.3)	178	(58.7)	
Residence by sub-district							**0.034***
Chan Chwa	0	(0)	18	(58.1)	13	(41.9)	
Chan Chwa Tai	3	(6.4)	21	(44.7)	23	(48.9)	
Chom Sawan	3	(11.1)	11	(40.7)	13	(48.2)	
Mae Chan	7	(3.3)	80	(38.3)	122	(58.4)	
Mae Kam	9	(12.3)	31	(42.5)	33	(45.2)	
Mae Rai	1	(1.1)	31	(35.2)	56	(63.7)	
Pa Sang	3	(2.7)	45	(41.3)	61	(55.0)	
Pa Tung	17	(6.3)	100	(37.0)	153	(56.7)	
Son Sai	2	(5.4)	19	(51.4)	16	(43.2)	
Sri Kam	2	(4.8)	23	(54.7)	17	(40.5)	
Tha Kao Pluang	6	(9.1)	26	(39.4)	34	(51.5)	
Maternal Age (year-old)							**0.361**
< 20	5	(2.6)	82	(43.2)	103	(54.2)	
20-29	28	(5.4)	209	(40.3)	282	(54.3)	
30-39	15	(6.6)	96	(42.1)	117	(51.3)	
≥ 40	3	(12.5)	8	(33.3)	13	(54.2)	

Table 1C. Characteristics among birth weight group of children. (Continued)

Variables	Birth weight (kg.)						p
	<2.5	(%)	2.5-3.0	(%)	>3.0	(%)	
Multiple pregnancy							**0.002***
No	17	(4.1)	194	(47.1)	201	(48.8)	
Yes	36	(6.3)	206	(36.0)	331	(57.7)	
Parity							**0.003***
Nulliparous	21	(4.7)	207	(46.4)	218	(48.9)	
Parous	26	(5.8)	159	(35.2)	266	(59.0)	
Birth spacing (years)							**0.217**
< 5	15	(6.4)	74	(31.5)	146	(62.1)	
≥ 5	17	(6.1)	108	(38.9)	153	(55.0)	
Delivery method							**0.003***
Normally	38	(4.8)	325	(40.9)	432	(54.3)	
Cesarean	10	(6.1)	61	(37.4)	92	(56.5)	
Other	5	(18.5)	10	(37.0)	12	(44.5)	

*Significance level at 0.05

From Table 1C, birth weight among male and female children were significant different (p=0.001). Most of male were born with birth weight more than 3.0 kg., while as female were mostly born with birth weight more than and equal 2.5 kg. Birth weight among residence areas were significant different (p=0.034). Mother who lived in Chan Chwa, Son Sai, and Sri Kam Sub-district, were delivered children with birth weight 2.5 to 3.0 kg. In the other hand, mother who lived in Chan Chwa Tai, Chom Sawan, Mae Chan, Mae Kam, Mae Rai, Pa Sang, Pa Tung, and Tha Kao Pluang, were delivered children with birth weight more than 3.0 kg. The children who born in multiple pregnancy mothers had birth weight significant different from single pregnancy mothers (p=0.002). Birth weight among children who were born to nulliparous woman were significant different from parous (p=). In addition, delivery method was significant affected to birth weight (p=0.003).

In contrast, birth weights among lowland and hilltribe children were not different (p=0.155). Maternal age and birth spacing did not affect to birth weight.

APPENDIX D
IMMUNIZATION SCHEDULE FOR CHILDREN IN THAILAND

ตารางการฉีดวัคซีน

อายุ	วัคซีนที่อยู่ในแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	วัคซีนที่อยู่นอกแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	อาการแทรกซ้อนและข้อแนะนำ
แรกเกิด	1. วัณโรค 2. ตับอักเสบบี เข็มที่ 1	-	- ถ้ามารดาเป็นพาหะของตับอักเสบบี ควรให้วัคซีนเร็วที่สุด
1 เดือน	1. ตับอักเสบบี เข็มที่ 2	-	- อาจให้ได้เมื่ออายุ 2 เดือน
2 เดือน	1. คอตีบ ไอกรน บาดทะยัก เข็มที่ 1 2. โปลิโอ หยดครั้งที่ 1	1. เยื่อหุ้มสมองอักเสบบี เข็มที่ 1	- หลังให้วัคซีนอาจมีไข้ได้ 1-2 วัน- วัคซีนเยื่อหุ้มสมองอักเสบบี แนะนำให้ใน เด็กอายุน้อยกว่า 2 ปี ที่อยู่กันอย่างแออัด หรือในสถานรับเลี้ยงเด็ก - วัคซีนเยื่อหุ้มสมองอักเสบบีอาจรวมกับวัคซีนคอตีบ ไอกรน บาดทะยัก เป็นเข็มเดียว
4 เดือน	1. คอตีบ ไอกรน บาดทะยัก เข็มที่ 2 2. โปลิโอ หยดครั้งที่ 2	1. เยื่อหุ้มสมองอักเสบบี เข็มที่ 2	- หลังให้วัคซีนอาจมีไข้ได้ 1-2 วัน

ตารางการฉีดวัคซีน (ต่อ)

อายุ	วัคซีนที่อยู่ในแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	วัคซีนที่อยู่นอกแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	อาการแทรกซ้อนและข้อแนะนำ
6 เดือน	1. คอตีบ ไอกรน บาดทะยัก เข็มที่ 3 2. โปลิโอ หยดครั้งที่ 3 3. ตับอักเสบบี เข็มที่ 3	1. เยื่อหุ้มสมองอักเสบบี เข็มที่ 3	- หลังให้วัคซีนอาจมีไข้ได้ 1-2 วัน - ปัจจุบันมีวัคซีนรวมของคอตีบ ไอกรน บาดทะยัก กับตับอักเสบบี และสามารถรวมกับวัคซีนเยื่อหุ้มสมองอักเสบบีบางชนิดได้
9 เดือน	1. หัด หัดเยอรมัน คางทูม เข็มที่ 1	-	- หลังฉีด 5-7 วัน อาจมีไข้ มีผื่น1-2 วัน
12-15 เดือน	1. ไข้สมองอักเสบ เข็มที่ 1, 2	-	- เข็มที่ 2 ห่างจากเข็มแรก 1-4 สัปดาห์
18 เดือน	1. คอตีบ ไอกรน บาดทะยัก เข็มกระตุ้นที่ 1 2. โปลิโอ หยอดกระตุ้นครั้งที่ 1	-	- หลังให้วัคซีนอาจมีไข้ได้ 1-2 วัน
2 ปี	1. ไข้สมองอักเสบเข็มที่ 3	-	-
3 ปี	-	1. ตับอักเสบเอ เข็มที่ 1, 2	- อาจให้เมื่ออายุ 4-6 ปี เข็มสองห่างจากเข็มแรก 6-12 เดือน
4 ปี	1. คอตีบ ไอกรน บาดทะยัก เข็มกระตุ้นที่ 2 2. โปลิโอ หยอดกระตุ้นครั้งที่ 2	-	- หลังให้วัคซีนอาจมีไข้ได้ 1-2 วัน

ตารางการฉีดวัคซีน (ต่อ)

อายุ	วัคซีนที่อยู่ในแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	วัคซีนที่อยู่นอกแผนการสร้างเสริมภูมิคุ้มกันโรคของกระทรวงสาธารณสุข	อาการแทรกซ้อนและข้อแนะนำ
5-6 ปี	1. หัด หัดเยอรมัน คางทูม เข็มที่ 2	-	- หลังฉีด 5-7 วัน อาจมีไข้ มีผื่น 1-2 วัน
6-10 ปี	-	1. ไทฟอยด์	- ไม่แนะนำในเด็กไทย - แนะนำเมื่อจะเดินทางไปในแดนที่มีการระบาด
10-12 ปี	-	1. สุกใส	- สำหรับคนที่ยังไม่เคยเป็นสุกใสมาก่อน - หากอายุมากกว่า 12 ปี ต้องฉีด 2 เข็มห่างกัน 4-8 สัปดาห์

เอกสารอ้างอิง

กุลกัญญา โชคไพบูลย์กิจและอังกูร เกิดพาณิช. คู่มือการใช้วัคซีนสำหรับเด็กไทย 2545. ชมรมโรคติดเชื้อแห่งประเทศไทย. ครั้งที่ 1. เนติกุลการพิมพ์ (2541) จำกัด: กรุงเทพ, 2545

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