Impact of Stunting on Cognitive Function of Children in Southern Thailand: Based on the Prospective Cohort Study of Thai Children

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บทคัดย่อ

การศึกษาครั้งนี้มีวัตถุประสงค์เพื่อศึกษาความชุกของสภาวะเตี้ยแคระแกร็นและศึกษาความสัมพันธ์ระหว่างสภาวะเตี้ยแคระแกร็นกับสติปัญญาของเด็กในภาคใต้ ข้อมูลในการศึกษาได้รับจากโครงการวิจัยระยะยาวในเด็กไทย อำเภอเทพา จังหวัดสงขลา วัดระดับสติปัญญาของเด็กที่อายุ 8 ปีครึ่ง ด้วยแบบทดสอบ Test of Nonverbal Intelligence 3rd Edition (TONI-3) จำนวน 924 คน ทำการวิเคราะห์ข้อมูลด้วยแบบจำลองการถดถอยเชิงเส้น

ผลการศึกษาพบว่า ระดับสติปัญญาเฉลี่ยของกลุ่มตัวอย่าง คือ 86.2±8.8 คะแนน มารดาส่วนใหญ่มีระดับการศึกษาในระดับประถมศึกษา (61.36%) เด็กส่วนใหญ่มากจากครอบครัวที่มีรายได้น้อยกว่า 10,000 บาทต่อเดือน คิดเป็นร้อยละ 60 และมากกว่าครึ่งหนึ่งเป็นเด็กผู้ชาย (52.38%) เด็กที่มีภาวะเตี้ยแคระแกรนที่อายุต่ำกว่าหนึ่งปี 1 ปี 3 ปี 5 ปี และ 8 ปีครึ่ง คิดเป็นร้อยละ 7.18 12.81 24.18 21.48 และ 21.57 ตามลำดับ การเลี้ยงลูกด้วยนมแม่อย่างเดียว ณ ที่เด็กอายุ 21 วัน 3 เดือน 6 เดือน และ 12 เดือน คิดเป็นร้อยละ 50.65 47.23 50.93 และ 45.69 ตามลำดับ และเพียงร้อยละ 9.15 ของกลุ่มเด็กที่ศึกษามีน้ำหนักแรกเกิดต่ำกว่า 2,500 กรัม ปัจจัยที่มีความสัมพันธ์กับระดับสติปัญญาของเด็ก คือ การศึกษาของมารดา รายได้ของครอบครัว และภาวะเตี้ยแคระแกร็นที่อายุต่ำกว่า 1 ปี โดยเด็กที่มีมารดามีระดับการศึกษาระดับปริญญาตรีมีสติปัญญาสูงกว่าค่าเฉลี่ยโดยรวม ส่วนเด็กที่มาจากครอบครัวที่รายได้มากกว่า 15,000 บาทต่อเดือน มีสติปัญญาสูงกว่าค่าเฉลี่ยโดยรวม ในขณะที่เด็กที่มาจากครอบครัวที่มีรายได้น้อยกว่า 10,000 บาทต่อเดือน มีสติปัญญาต่ำกว่าค่าเฉลี่ยโดยรวม และเด็กที่มีภาวะเตี้ยแคระแกร็นที่อายุน้อยกว่า 1 ปี มีสติปัญญาต่ำกว่าค่าเฉลี่ยโดยรวม

โดยสรุป การส่งเสริมพัฒนาการด้านสติปัญญาของเด็ก ควรเน้นการป้องกันการเกิดภาวะเตี้ยแคะแกร็นในช่วงขวบปีแรกของเด็ก และให้ความรู้ด้านโภชนาการแก่มารดาที่มีการศึกษาต่ำและครอบครัวที่มีรายได้น้อย

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ABSTRACT

This study aimed to investigate the prevalence of stunting children in Southern Thailand from the Prospective Cohort Study of Thai Children, and to also identify the associations between stunting and the cognitive function of children in Southern Thailand. Data were obtained from the Prospective Cohort Study of Thai Children (PCTC) in Thepha district, Songkhla province. Children's intelligence quotients (IQ) were tested by using Test of Nonverbal Intelligence 3rd Edition (TONI-3) from 924 children at age 8.5 years. Multiple linear regression was used to identify the factors associated with cognitive function.

The average IQ score of children was 86.2. Most of mothers had access to primary education (61.36%). Children from families with incomes less than 10,000 Baht per month accounted for 60% and more than half of the children were males (52.38%). Stunted children at ages less than 1, 1, 3, 5 and 8.5 years accounted for 7.18%, 12.81%, 24.18%, 21.48% and 21.57%, respectively. Mothers who exclusively breast fed their children at ages of 21 days, 3, 6, 12 months accounted for 50.65%, 47.23%, 50.93% and 45.69%, respectively. About 9% of children were born with low birth weight. Maternal education, family income and stunting at age less than one year were significantly

associated with cognitive function. Children whose mothers attained Bachelor's degree had higher cognitive function than the average. Children from family with income more than 15,000 Baht per month also had higher cognitive function than the average, where as children form families with income less than 10,000 Baht per month tended to have cognitive function lower than the average. Stunted children at birth tended to have lower cognitive function than the average.

In conclusion, improving cognitive function among children should be emphasized on preventing stunting at the first year of age, providing nutrition knowledge for low educated mother and low income family.

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Fatina Samae

Chapter 1

Introduction

1.1 Background and rationale

Cognitive function is an intellectual process by which one becomes aware of, perceives, or comprehends ideas. It involves all aspects of perception, thinking, reasoning, and remembering (Mosby Inc, 2009). In 2001, it was estimated that in developing countries more than 200 million preschool children do not reach their full cognitive potential (UNICEF, 2001). Lynn (2006) conducted a study of race differences in intelligence among human from 133 countries and countries found that the average intelligence quotient was 90. In Thailand, Mongkol *et al*. (2012) used the Standard Progressive Matrices (SPM) to measure IQ and revealed that the average IQ of Thai children, aging 7 to 15 years, was 98.6. The lowest average IQ score of Thai children was found in the Northeast with the average of 95.9, followed by those from Southern Thailand with an average of 96.9.

There are many factors associated with cognitive function. Genetic, environmental, and social factors are important determinants of cognitive development and behavior (Plomin *et al*, 1994). It is important to be aware of the risk factors that affect cognitive function, especially during the first 2 years of life, a critical period of rapid growth and development (Berkman *et al*, 2002). Stunting during the first 2 years of life for children is associated with poor cognitive development in late childhood as reported in Philippines (Mendez and Adair, 1999), and in Peru (Berkman *et al*, 2002). Stunting is an indicator of chronic malnutrition and can occur in children in of all ages, which

can be occurred in low socioeconomic family (Mongkolchati *et al*, 2010) Stunting is accompanied by a delay in physical and cognitive development (Branca and Ferrari, 2002).

It is estimated that, in 2010, 171 million children in the world were stunted. Of these, among these children, 167 millions of them. Globally, childhood stunting decreased from 39.7% in 1990 to 26.7 % in 2010 (de Onis *et al*, 2012). When looking at the prevalence of stunting in Africa and Asia, stunting rates are particularly high, at 40 % and 36 % respectively. More than 90% of the developing world's stunted children live in Africa and Asia (UNICEF, 2009).

The prevalence of stunting in Thai children aging 1 to 5 years was 6.3% (Health System Research Institute, 2010). Many studies have confirmed that stunting during childhood is associated with a decrease in cognitive function. However, the studies of the impact of stunting on cognitive function in Thailand are limited.

This study aims to identify the associations between stunting and the cognitive function of children in Southern Thailand. The results from this study will be useful for setting up nutrition planning for children in the region.

1.2 Objectives

The objectives of this study are to investigate the prevalence of stunting children in Southern Thailand from the Prospective Cohort Study of Thai Children, and to also indentify the associations between stunting and the cognitive function of children in Southern Thailand.

1.3 Expected advantages

As an expected result of this study, the prevalence of stunting and its impact on cognitive function of children in Southern Thailand will be revealed. The findings of this study will provide useful information for the setting up of a nutrition plan for children in Southern Thailand

1.4 Literature reviews

Impact of Stunting on Cognitive Function

The effects of stunting on the cognitive function of children have been studied in many developing countries. In Jamaica, stunting in early childhood was associated with cognitive and educational deficits in late adolescence (Walker *et al*, 2005). In Ethiopia, Bogale *et al*. (2013) conducted a study of nutritional status and cognitive performance of women and their 5-year-old children. This study reported that there was a significant difference in the mean cognitive test scores of stunted and non-stunted children.

A study conducted by Berkman *et al*. (2002) in Peru revealed that during the first and second years of life, 32% of children were stunted. Using the Wechsler Intelligence Scale for Children-Revised (WISC-R) test, they found that children with severe stunting in the second year of life had average IQ scores10 points lower than children who were not severely stunted. Mendez and Adair (1999) conducted a study of the severity and timing of stunting during the first two years of life, and the affect of these on performance and results from cognitive tests given to 2,131 Filipino children. The results showed that children stunted since birth and at age of 2 years had significantly

lower test scores than non-stunted children at these ages. In Indonesia, Webb *et al*. (2005) conducted a study of parental IQ and cognitive development of malnourished Indonesian children. The results from this study showed the severely stunted children had significantly lower IQs than mild–to moderately stunted children.

In Bangladesh, Tarleton *et al*. (2006) conducted a study of 191 Bangladeshi children, aged 6 to 9 years, using verbal and non-verbal tests. This study reported that cognitive scores were negatively associated with stunting during school age, as well as the height-for-age and weight-for-age scores at enrollment.

Other factor affecting on cognitive function

Maternal education

Meehan (2010) conducted a study in United States, and 2,997 participants were recruited, the process was to assign participants to either receive Early Head Start (EHS) services (1,503 participants), or not to receive EHS services (1,474 participants) randomly. This study reported that EHS was positively associated with cognitive development among children from a mother with a high school diploma. In Thailand, Nanthamongkoichai *et al*. (2003) conducted a study of 266 children aged 6 to 12 years from four provinces in Thailand: Phrae, Burirum, Saraburi and Bangkok. Colored and Standard Progressive Matrices (SPM) were used to test development. This study reported that mothers who had received elementary education or higher were more likely to have children with normal intelligence than mothers who had a lower education level.

Family income

Numerous studies have indicated that household income, or the income earned by the child‘s primary caretaker, is one of, if not the most significant determinant in a child’s cognitive development. To et al. (2004) conducted the National Longitudinal Survey of Children and Youth (NLSCY) in Canada from1994 to 1995 and from 1996 to 1997. They found that a low income was a significant predictor of poorer cognitive function across all age groups. In Thailand, Kumpermpool (1996) conducted a study of intellectual level, growth and health status of children aging 6 to 12 years in central region of Thailand. The data were obtained from a survey of population change during 1995-1996 in eight provinces of the Central region of Thailand. The results from this study showed that families with higher incomes tended to have children with higher IQs. Sangruang and Plubrukarn (2012) conducted a study of 215 children aging 10 to12 from Bangkok Metropolitan Administration schools. Tests of Non-verbal Intelligence, third edition (TONI-3) were used. This study reported that family income was statistically significantly associated with a child’s IQ.

Gender

A study on comparison of gender performance on an intelligence test among medical students conducted by Ali *et al*. (2009) found the male students had IQ scores higher than the female studens. In Thailand, Wongpiromsarn *et al*. (2012) conducted a study of 72,780 children from grade 1 to grade 9 students in Thailand reported that girls had higher development of intelligence than boys.

Infant feeding methods

Park *et al*. (2014) conducted a study of protective effect of breastfeeding with regard to children's behavioral and cognitive problems in Korean reported that breastfeeding had are effect on childhood intelligence. Children breastfed for eight months or longer had mean verbal IQ scores 10.2 points higher and performance IQ scores that were 6.2 points higher than children who did not receive breast milk (Horwood et al., 2001)

Low birth weight

Low birth weight is closely correlated with the death and illness of the fetus and newborn, inhibited growth, cognitive development and subsequent risk of chronic disease (Barker, 1992). In Britain, Richards *et al*. (2001) conducted a study of 3,900 males and females born in 1,946. Using various cognitive measures, subjects were tested at ages of 8, 11, 15, 26 and 43 years. This study reported birth weight was significantly and positively associated with cognitive ability at age of 8 years.

A study conducted by Martínez-Cruz *et al*. (2006) in Mexico revealed that the IQ scores of children born with extremely low birth weight (ELBW) were significantly lower when compared to children born with a higher birth weight. In USA, Ceadle and Goosby (2010) revealed that lower birth weight, even after adjusting for fixed-family characteristics and aspects of the home environment that varying between siblings, was associated with decreased cognitive skills at age of 5 years.

Intelligence quotient surveys in Thai children

The overall level of cognitive function can be measured from an intelligence quotient (IQ) test (Holdnack, 2003). We reviewed seven intelligence quotient surveys conducted between 1989 and 2011. All of these surveys used three stages cluster sampling method for children aged 6-13 years old. Six different IQ tests were used from the different surveys: the Thai test of the intelligent capability of children between the ages of 2-15 years, test of Nonverbal Intelligence second edition (TONI-2), test of Nonverbal Intelligence second edition (TONI-3), Wechsler Intelligence Scale for Children- third edition (WISC-II), Raven's Coloured Progressive Matrices (CPM) and the Standard Progressive Matrices (SPM) (Pollitt et al.,1989; Ruangdaraganon, 1998; Vanitrommanee et al., 2004; Mohsuwan et al., 2004; Chakraphand et al., 2010; Mohsuwan et al., 2011; Mongkol et al, 2012). The average IQ of Thai children in each region was different according to the use of different IQ test.

CPM is designed to assess non-verbal for children aged 5 through 11 years and the elderly. Even though CPM test is similar to SPM test but this test is designed for measuring IQ among general population. The example of using this test is the measurement of iron-deficiency anemia children by Pollitt *et al*. (1989) to measure children IQ aged 9-11 years. They found that the average of IQ in this group was 90.8.

SPM was used by Mongkol *et al*. (2012). They conduct a study from 72,780 Thai students in primary and secondary school aged 6-15 years old and found that the average IQ of this group was 98.6.

WISC-III is another test for measuring IQ. This test is designed to measure human intelligence as reflected in both verbal and nonverbal abilities. It is designed for subjects ranging in age from 6 years, 0 months through 16 years, 11 months (Wechsler, 1991). Vanitrommanee *et al*. (2004) used this test to measure the IQ of 3,300 Thai students from primary school in Office of the Basic Education Commission of Thailand and Department of General Education 13 Department in Thailand. They collected children aged 6-16 and found that the average IQ was 98.4.

TONI-2 is designed to test nonverbal abstract or figural problem solving in individual. It is designed for subjects ranging in age from 5 years through 85 years. TONI-2 is an ideal test for those who have linguistic difficulties or who are culturally different (Brown *et al*, 1990). The example of using this test is Ruangdaraganon (1998) applied this test to measure IQ of children age from 6 years, 0 months through 12 years, 11 months. This study reported that the average IQ of children was 92.

The current version of TONI test is TONI-3. Mohsuwan *et al*. (2004) and Mohsuwan *et al*. (2011) used this test in 2 different surveys. The first survey was conducted to measure the IQ from 3,135 students in 4 regions of Thailand which was Bangkok, Mid-region, Northern region, North-Eastern region and Southern region. The results showed that the average IQ was 88.1. The second survey was conducted to measure the IQ from 5,998 students from 21 provinces in 4 different regions of Thailand and found that the average IQ was 91.4.

The Thai test of the intelligent capability of children between the ages of 2-15 years was developed by clinical psychologists of the Department of Mental Health was

applied in this study. The average IQ of 4,967 primary school students from 4 regions in Thailand measured by this test was 97.3 (Chakraphand *et al*, 2010).

Summary

The literature has revealed that maternal education, family income, gender, stunting at aged of 0, 1, 3, 5 and 8.5 years, infant feeding methods at aged of 21 days, 3, 6 and 12 months, low birth weight are all positively associated with cognitive function. In the next few chapters, this study investigates the association between determinants and cognitive function of children from Thepa district, Songkla province, Southern Thailand. Our findings are largely in agreement with the authors mentioned in this chapter.

Chapter 2

Methodology

This chapter describes the methods used in this study including study design, data collection and management, path diagram, variables and statistical methods. Graphical and statistical analyses were performed by using R programming environment.

2.1 Study design

A retrospective study of 1,076 children, from their birth in 2000-2001 until they were eight and a half years of age, was carried out on children from Thepa district, Songkhla province, Southern Thailand.

2.2 Data collection and management

Data collection

Data relating to the cognitive development of children and their growth rates were obtained from the Prospective Cohort Study of Thai Children (PCTC) project. The PCTC is a population-based study. The study began in 2000 and the data were collected from five districts in four different provinces, namely Pamomtuan district, in Khon Kaen province (West), Thepa district, in Songkhla province (South), Kranuan district, in Khon Kaen province (Northeast), Muang district, in Nan province (North) and a hospital-based cohort in Bangkok. Pregnant women from the aforementioned five districts were selected using a purposive sampling method. Socio-demographic

information was obtained from each pregnant woman who gave an interview. The women and their children were followed up until the year 2009. Data on weight, height, infant feeding methods at ages of 0, 1, 3, 5 and 8.5 years were collected. Data from the Thepa district, Songkhla province were selected as a sub-sample for this study to include 1,076 infants.

Data management

Measurements of cognitive function from the Prospective Cohort Study of Thai Children were recorded in a text file. Error checking was performed to identify coding errors, missing or extreme values. Following the error checking process, we found that there were 152, or 14.13% of missing values of thus all in these records, and therefore omitted these values from this study. Consequently, the information relating 924 children were used for further analysis. The R programming environment (R Development Core Team, 2010) was used for producing all graphical displays and performing statistical data analysis in this study.

2.3 Path diagram and variables

Path diagram

A path diagram is a schematic diagram showing the relationship between the determinant and outcome variable. The determinants are maternal education, family income, gender, stunting at ages of 0, 1, 3, 5 and 8.5 years, infant feeding methods at ages of 21 days, 3, 6 and 12 months, and low birth weight. The outcome of interest is cognitive function ability of children. The path diagram is shown in Figure 2.1

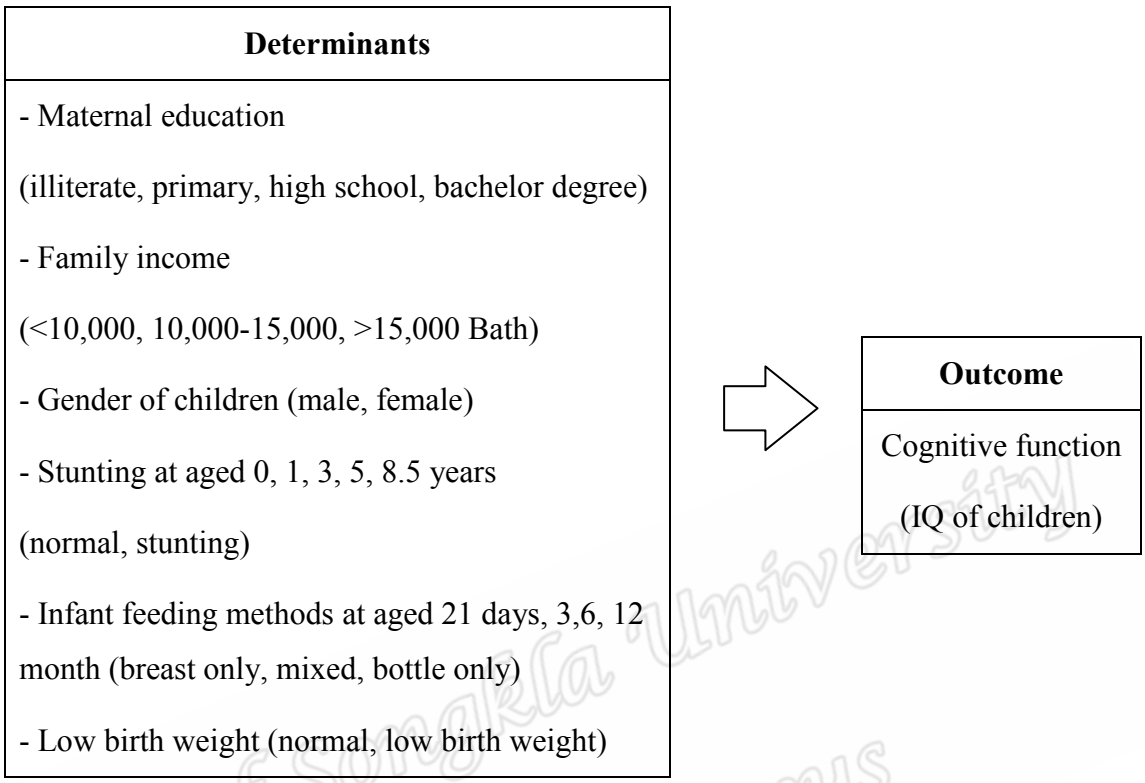

Figure 2.1: Path diagram for the study

Variables

Outcome

The outcome of this study is the cognitive function of children at ages of 8.5 years which was measured from using the intelligence quotient (IQ) obtained from a test of Nonverbal Intelligence 3rd Edition (TONI-3). TONI-3 is designed to test nonverbal abstract or figural problem solving abilities in individuals aged with ages of 6 years, and 0 months through to 89 years, and 11 month (Brown et al, 1997).

Determinants

The determinants are maternal education, family income, gender, stunting at aged of 0, 1, 3, 5 and 8.5 years, infant feeding methods at aged of 21 days, 3, 6 and 12 months and low birth weight.

Maternal education was divided into 4 groups: illiterate, primary, high school and bachelor degree.

Family income in Bath per month was divided into 3 groups: lower than 10,000, between 10,000 and 15,000 and higher than 15,000 Bath.

Height for age is a growth status expressed in standard deviation (SD) units (Z-score) from the median of the reference population. Children with a score lower than -2 SD units from the median of growth of the reference population were considered stunted, and children with a score lower than -3 SD units from the median of the reference population were considered severely stunted (World Health Organization, 2008.) Stunting at ages of 0, 1, 3, 5 and 8.5 years into 2 groups: normal (greater or equal to -2 SD), and stunting (lower than -2 SD) based on the WHO child growth standard reference data (WHO, 2008).

Infant feeding methods at aged of 21 days, 3, 6 and 12 months were divided into 3 groups: breast feeding, mixed feeding and formula feeding.

Low birth weight was divided into 2 groups: less than 2,500 grams and more than or equal to 2,500 grams.

2.4 Statistical methods

Multiple linear regression

Since cognitive function was considered as a continuous outcome and the determinants comprise maternal education, family income, gender, stunting at ages of 0, 1, 3, 5 and 8.5 years, infant feeding methods at aged of 21 days, 3, 6 and 12 months and low birth weight, multiple linear regression analysis was the appropriate method for statistical modeling in this study. The estimated multiple linear regression model takes the form:

$$y_{ijkmns} = \mu + \alpha_i + \beta_j + \gamma_k + \lambda_m + \rho_n + \sigma_s \quad (1)$$

where y_{ijkmns} is cognitive function, μ is the overall effect, α_i is the effect of family income i, β_j is the effect of stunting j, γ_k is the effect of gender k, λ_m is the effect of maternal education m, ρ_n is the effect of infant feeding method n, and σ_s is the effect of low birth weight s. The model was fitted to the data using the method of least squares, which minimizes the sum of squares of the residuals. Linear regression analysis is set on three assumptions including the association is linear, the variability of the errors (in the outcome variable) is uniform and these errors are normal distributed. If these assumptions were not met, the data may need to be transformed. Linear regression analysis can be performed for both continuous and categorical determinants. In the model, each categorical determinant is broken down into c-1 parameters, where c is the number of categories. The omitted category was taken as the baseline or reference category.

The continuous outcome variable was defined as the cognitive function. The rates generally have positively skewed distributions so it is conventional to transform them by taking logarithms. The estimated additive model for cognitive function is taken the form

$$In(y_{ijkmns}) = \mu + \alpha_i + \beta_j + \gamma_k + \lambda_m + \rho_n + \sigma_s \qquad (2)$$

Chapter 3

Preliminary Data Analysis

In this chapter, we describe the preliminary data analysis for cognitive function of children in Southern Thailand. A total of 1,076 children from Thepa district, Songkhla province, Southern Thailand since birth to eight and a half years were included in this study. The results are presented using frequency table and graphical display for identifying the association between determinants and an outcome variable.

3.1 Distributions of the variable

The roles of the variable are classified as determinants and an outcome. These variables with their roles and data types are listed in Table 3.1.

Table 3.1: Variables and their roles

Variables	Types	Measurement real
Maternal education	Determinant	Nominal
Family income	Determinant	Nominal
Gender	Determinant	Binary
Stunting at ages of 0, 1, 3, 5 and 8.5 years	Determinant	Nominal
Infant feeding methods at ages of 21 days, 3, 6 and 12 months	Determinant	Nominal
Low birth weight	Determinant	Binary
Cognitive function	Outcome	Continuous

3.2 Distributions of determinants

The frequency distributions for determinants are shown in Table 3.2. Most of mothers had a primary educational level. Children from family incomes less than 10,000 Baht per month were accounted for 60% and more than half of children were males (52.38%). Stunted children at ages less than 1, 1, 3, 5 and 8.5 years accounted for 7.18%, 12.81%, 24.18%, 21.48% and 21.57%, respectively. Mothers fed their children at ages of 21 days, 3, 6, 12 months by breast feeding only accounted for 50.65%, 47.23%, 50.93% and 45.69%, respectively. Only 9.15% of children were low birth weight.

Table 3.2: Distribution of mothers and their children characteristics

Factors	Number	Percentage
Maternal data		
Maternal education		
Illiterate	55	5.95
Primary	567	61.36
High School	275	29.76
Bachelor degree	27	2.92
Family income bath/ month		
<10,000	554	59.96
10,000-15,000	144	15.58
>15,000	226	24.46

Table 3.2: (cont.)

Factors	Number	Percentage
Children data		
Gender		
Male	484	52.38
Female	440	47.62
Stunting at birth (0 year)		
Normal	801	92.82
Stunting	62	7.18
Stunting at ages of 1 year		
Normal	796	87.19
Stunting	117	12.81
Stunting at ages of 3 years		
Normal	696	75.82
Stunting	222	24.18
Stunting at ages of 5 years		
Normal	724	78.52
Stunting	198	21.48
Stunting at ages of 8.5 years		
Normal	766	78.87
Stunting	152	21.57

Table 3.2: (cont.)

Factors	Number	Percentage
Infant feeding methods at ages of 21 days		
Breast feeding	516	50.65
Mixed feeding	376	29.07
Formula feeding	30	19.74
Infant feeding methods at ages of 3 months		
Breast feeding	435	47.23
Mixed feeding	373	40.50
Formula feeding	113	12.27
Infant feeding methods at ages of 6 months		
Breast feeding	467	50.93
Mixed feeding	268	29.23
Formula feeding	182	19.85
Infant feeding methods at ages of 12 months		
Breast feeding	419	45.69
Mixed feeding	253	27.59
Formula feeding	245	26.72
Low birth weight		
Normal	804	90.85
Low birth weight	81	9.15

3.3 Distribution of cognitive function

In this study cognitive function is an outcome. The distribution of cognitive function had positively skewed. The cognitive function were violated the assumptions for a linear regression model. So it was conventional to transform them by applying logarithms. Figure 3.1 shows the histogram of cognitive function before transformation (left panel) and the histogram of cognitive function after transformation (right panel)

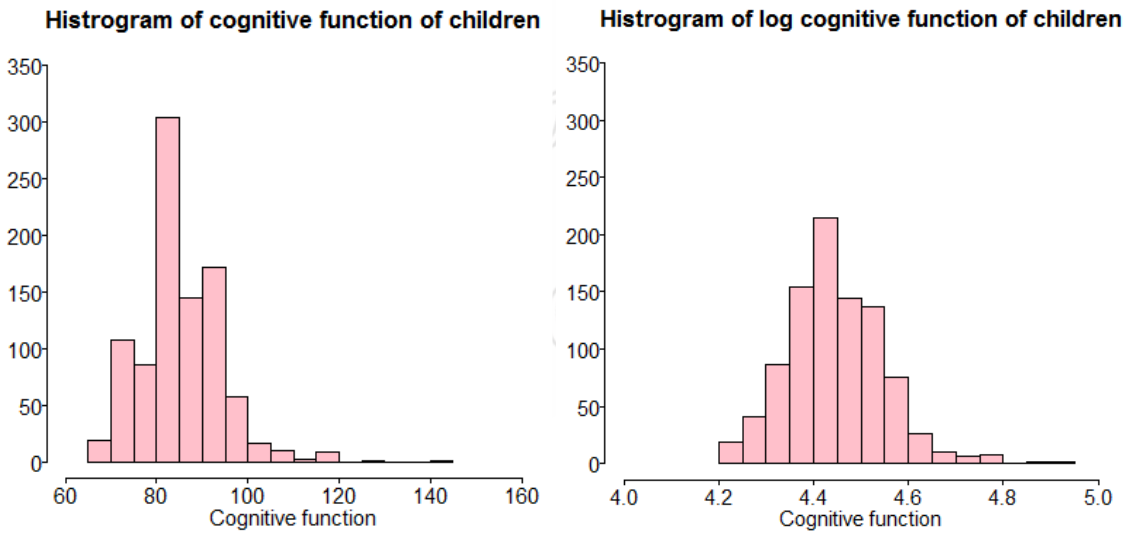

Figure 3.1: The distribution of cognitive function

3.4 Distribution of Cognitive function of each determinant

3.4.1 Distribution of Cognitive function of maternal education

In Figure 3.2, the box plot shows a distribution pattern of cognitive function of children at 8.5 years separated by maternal education. The X axis represents maternal education level, while the Y axis represents cognitive function of children. This graph shows that the highest median of IQ of children was found in mothers had bachelor degree level followed by mothers had high school level, mothers had primary level and mother had illiterate level.

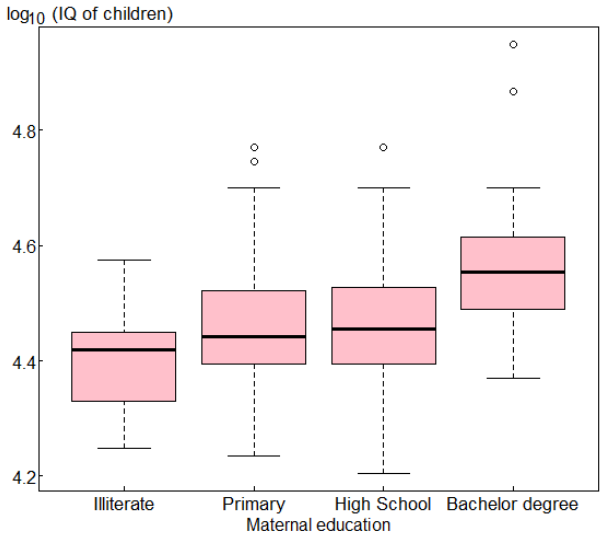

Figure 3.2 Distribution of cognitive function of maternal education

3.4.2 Distribution of Cognitive function of family income

Figure 3.3 shows the distribution of cognitive function of children at 8.5 years separated by family income. The box plot shows the highest median of IQ of children from family income more than 15,000 Baht per month, followed by children from family income between 10,000 and 15,000 Baht per month and children from family income less than 10,000 Baht per month.

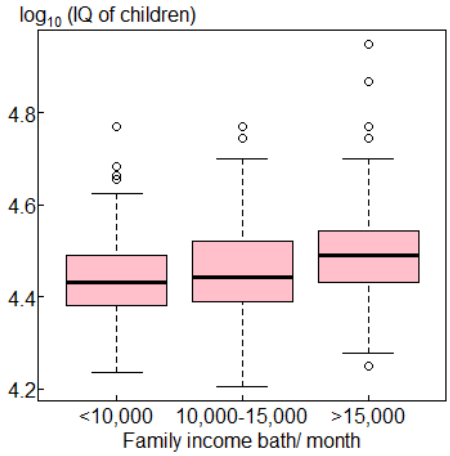

Figure 3.3 Distribution of cognitive function of family income

3.4.3 Distribution of Cognitive function of gender

In Figure 3.4**,** the box plot shows the cognitive function of children at 8.5 years separated by gender. The numbers of outliers for female was found more than male. However the median of cognitive function for male and female are similar.

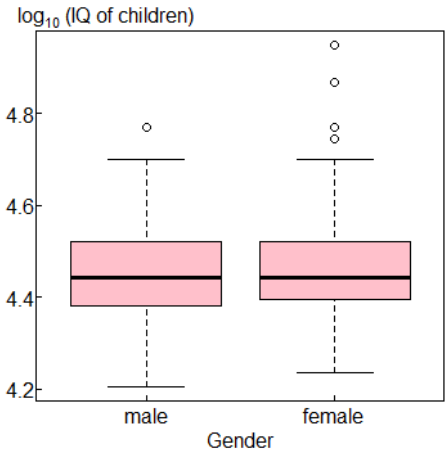

Figure 3.4 Distribution of cognitive function of gender

3.4.4 Distribution of Cognitive function of stunting

Figure 3.5 shows the distribution of cognitive function of stunting at birth, 1, 3, 5, and 8.5 years. This graph indicates that cognitive functions of the normal children were higher than stunting children in all of age groups.

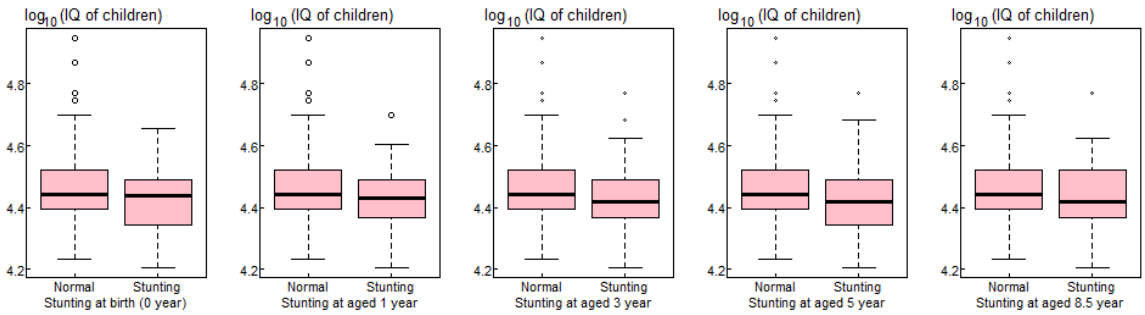

Figure 3.5 Distribution of cognitive function of stunting

3.4.5 Distribution of Cognitive function of infant feeding methods

Figure 3.6 shows the distribution of cognitive function of infant feeding methods at 21 days, 3, 6, 12 months. This graph represents the cognitive functions of infant feeding method at 21 days and 3 months are similar. After 6 and 12 months, the cognitive function of infant feeding by formula feeding has higher median than those of breast feeding and mixed feeding.

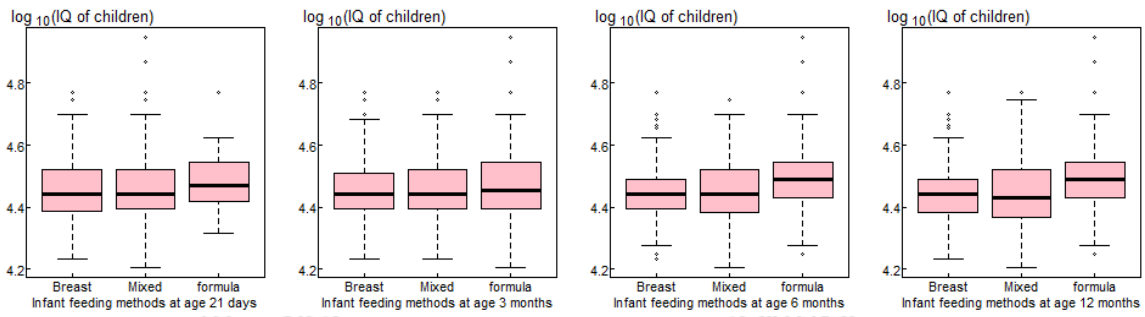

Figure 3.6 Distribution of cognitive function of infant feeding methods

3.4.6 Distribution of Cognitive function of low birth weight

In Figure3.7**,** the box plot shows the highest median of cognitive function of children were normal.

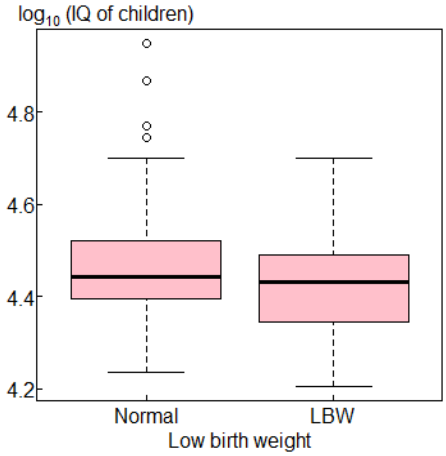

Figure 3.7 Distribution of cognitive function of low birth weight

3.5 Comparison of cognitive function for each determinant

Determinants with two categories are gender, stunting at ages of 0, 1, 3, 5 and 8.5 years and low birth weight. A two sample t-test was used for comparing the mean of cognitive functions for determinants with two categories, and ANOVA was used for comparing the mean of cognitive functions for determinants with more than two categories.

Table 3.3: Comparison of cognitive function for each determinant

Factors	Mean ± SD	P-value
Maternal data		
Maternal education		
Illiterate	81.96 ± 6.88	<0.001
Primary	85.62 ± 8.45	
High School	87.26 ± 8.44	
Bachelor degree	97.07 ± 13.33	
Family income bath/ month		
<10,000	84.74 ± 7.96	<0.001
10,000-15,000	86.03 ± 8.72	
>15,000	89.96 ± 9.76	
Children data		
Gender		
Male	85.63 ± 8.25	0.032
Female	86.88 ± 9.37	

Table 3.3: (cont.)

Factors	Mean ± SD	P-value
Stunting at birth (0 year)		
Normal	86.54 ± 8.85	0.010
Stunting	83.71 ± 8.02	
Stunting at aged 1 year		
Normal	86.53 ± 8.88	0.001
Stunting	83.88 ± 7.92	
Stunting at aged 3 years		
Normal	86.96 ± 8.94	<0.001
Stunting	84.00 ± 8.03	
Stunting at aged 5 years		
Normal	86.83 ± 8.72	<0.001
Stunting	84.07 ± 8.85	
Stunting at aged 8.5 years		
Normal	86.57 ± 8.85	0.012
Stunting	84.62 ± 8.57	
Infant feeding methods at age 21 days		
Breast feeding	85.62 ± 8.38	0.036
Mixed feeding	86.85 ± 9.37	
Formula feeding	88.70 ± 8.60	

Table 3.3: (cont.)

Factors	Mean ± SD	P-value
Infant feeding methods at age 3 months		
Breast feeding	85.57 ± 8.26	0.006
Mixed feeding	86.35 ± 8.68	
Formula feeding	88.50 ± 10.84	
Infant feeding methods at age 6 months		
Breast feeding	85.15 ± 7.94	<0.001
Mixed feeding	85.88 ± 8.62	
Formula feeding	89.29 ± 10.06	
Infant feeding methods at age 12 months		
Breast feeding	85.04 ± 7.72	<0.001
Mixed feeding	85.48 ± 9.21	
Formula feeding	89.00 ± 9.65	
Low birth weight		
Normal	86.46 ± 8.79	0.035
Low birth weight	84.25 ± 8.87	

The univariate analysis showed that gender, maternal education, family income, stunting at ages of 0, 1, 3, 5 and 8.5 years, infant feeding methods at ages of 21 day, 3, 6 and 12 months and having low birth weight were statistically significantly associated with cognitive function.

Chapter 4

Statistical Modeling

In this chapter, we describe the statistical method used in developing a model to predict the cognitive function of children using determinants associated with weights and heights of children at various ages and their feeding types (breast feeding, bottle feeding and mixed feeding) in the first year of life, as well as other demographic factors. We introduced a binary variable, stunting, to indicate whether the child's height-for age was "normal" or stunted. Children with height-for-age ratio less than -2 SD units from the median of growth of the reference population were considered stunted, and children with a ratio lower than -3 SD units from the median of the reference population were regarded as severely stunted. A linear regression was used for modeling and identifying the strength of the associations between the outcome and determinants. Sum contrasts were used to obtain confidence intervals for each level of each factor to enable a comparison with the overall mean.

4.1 Model fitting

A linear model was fit to the log transformed cognitive function outcome and maternal education, family income, gender, stunting at ages of 0, 1, 3, 5 and 8.5 years, infant feeding methods at ages of 21 days, 3, 6 and 12 months and having low birth weight (i.e. below 2.5 kg). The r-squared of log-linear model was 13.2%. The residuals plot in Figure 4.1 shows that only few residual values, accounted for less

than 5% of the overall values, depart from the diagonal line. Thus the normality assumption of residuals was acceptable.

4.2 Model diagnostics

Figure 4.1 shows the plot of residuals versus the normal quartile from log linear regression.

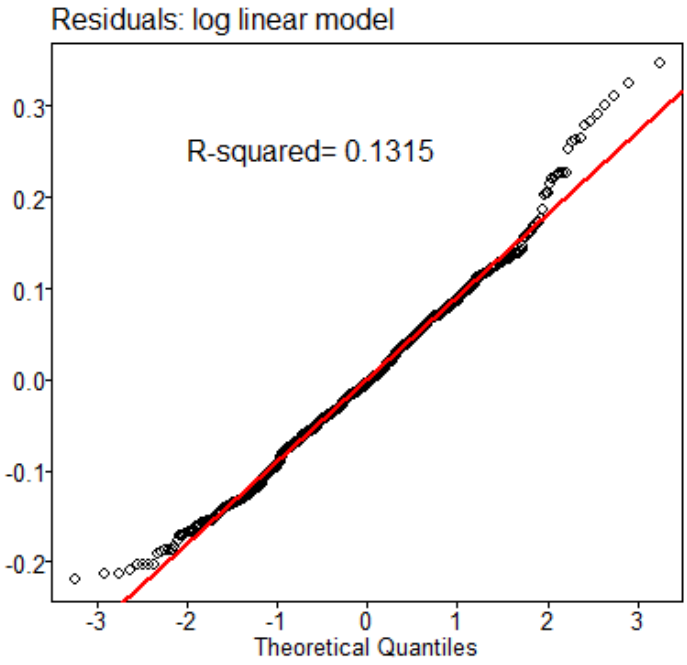

Figure 4.1: Residuals plot for log linear model

Table 4.1 shows the coefficients of parameters and their standard errors from log linear regression model using sum contrasts. The results showed that maternal education, family income and stunting at ages less than one year were statistically significantly associated with cognitive function of children.

Table 4.1: Coefficients, standard errors and p-values based on log-linear regression model fitted to cognitive function of children in Southern Thailand

Factors	Coefficients	SEs	P-value
Constant	4.456	0.011	<0.001
Maternal data			
Maternal education			
Illiterate	-0.047	0.012	<0.001
Primary	-0.015	0.007	0.036
High School	-0.009	0.008	0.251
Bachelor degree	0.071	0.016	<0.001
Family income Baht/ month			
<10,000	-0.015	0.005	0.001
10,000-15,000	-0.010	0.006	0.115
>15,000	0.025	0.006	<0.001
Child data			
Gender			
Male	-0.006	0.003	0.072
Female	0.006	0.003	0.072
Stunting at birth (0 year)			
Normal	0.016	0.008	0.033
Stunting	-0.016	0.008	0.033
Stunting at aged 1 year			
Normal	0.004	0.006	0.476
Stunting	-0.004	0.006	0.476

Table 4.1: (cont)

Factors	Coefficients	SEs	P-value
Stunting at aged 3 years			
Normal	0.006	0.006	0.347
Stunting	-0.006	0.006	0.347
Stunting at aged 5 years			
Normal	0.010	0.007	0.170
Stunting	-0.010	0.007	0.170
Stunting at aged 8.5 years			
Normal	-0.005	0.007	0.433
Stunting	0.005	0.007	0.433
Infant feeding methods at age 21 days			
Breast feeding	-0.001	0.008	0.931
Mixed feeding	-0.005	0.007	0.543
Formula feeding	0.005	0.014	0.702
Infant feeding methods at age 3 months			
Breast feeding	0.004	0.007	0.613
Mixed feeding	-0.005	0.005	0.314
Formula feeding	0.002	0.009	0.830
Infant feeding methods at age 6 months			
Breast feeding	-0.004	0.008	0.637
Mixed feeding	-0.003	0.006	0.640
Formula feeding	0.007	0.010	0.518

Table 4.1: (cont)

Factors	Coefficients	SEs	P-value
Infant feeding methods at age 12 months			
Breast feeding	-0.008	0.007	0.202
Mixed feeding	-0.004	0.006	0.555
Formula feeding	0.012	0.009	0.192
Low birth weight			
Normal	-0.002	0.007	0.752
Low birth weight	0.002	0.007	0.752

4.3 Confidence intervals for mean cognitive function

The graph of the 95% confidence intervals for the mean cognitive function of children for each factor from the log-linear regression model using sum contrasts are shown in Figures 4.2 and 4.3. The red horizontal line represents the overall mean of the cognitive function of children, which are 86.22 in both figures.

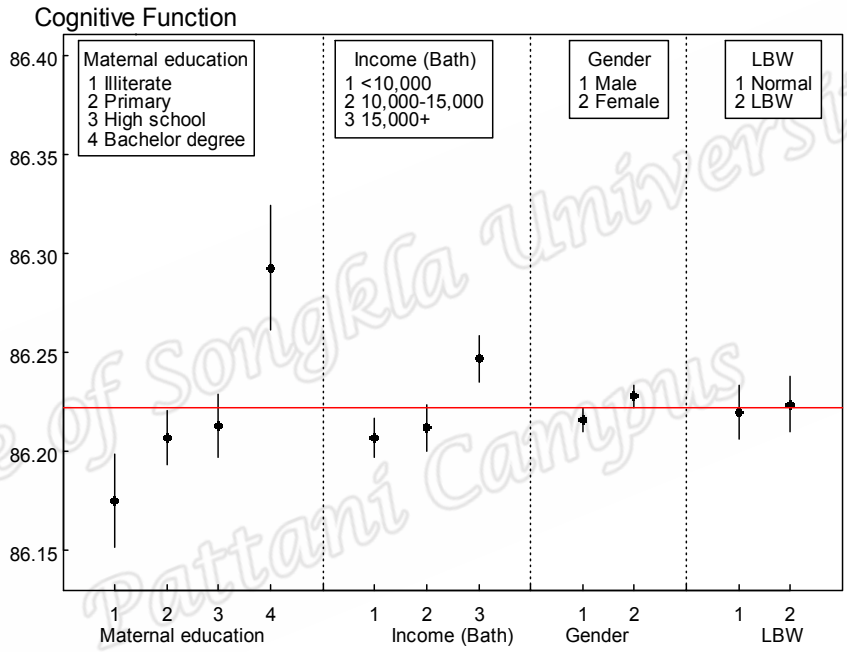

Figure 4.2: 95% confidence interval of mean cognitive function of children for levels of maternal education, family Income and the child's gender regardless of low birth weight

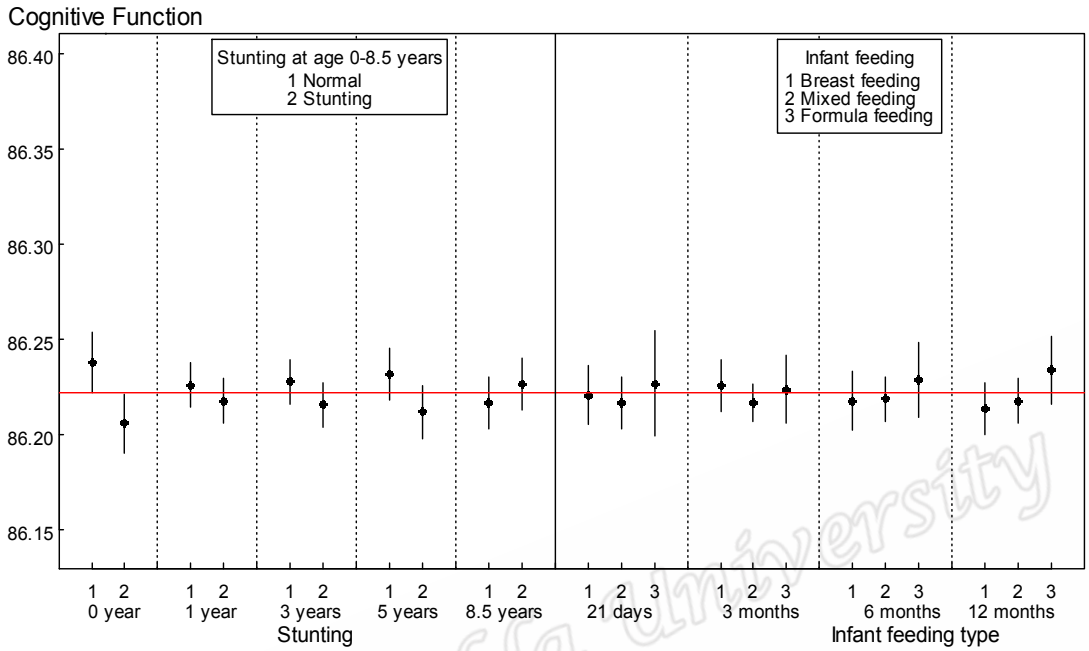

Figure 4.3: 95% confidence interval of mean cognitive function of children for levels of Stunting at different ages and different type of feeding as infant

Figures 4.2 and 4.3 show the 95% confidence intervals of the cognitive function of children based on the linear regression model separated by maternal education, family income, gender, low birth weight, stunting at ages of 0, 1, 3, 5 and 8.5 years and infant feeding methods at ages of 21 days, 3, 6, 12 months. The average cognitive function of children were significantly higher than the overall mean for children whose mothers attained a Bachelor's degree and for children from families with the highest income level (more than 15,000 Baht). The average cognitive functions of children were significantly lower than the overall mean for children whose mothers were illiterate and for children from families with the lowest income level (less than 15,000 Baht). There was no significant gender effect, however. The average cognitive functions of children, who were stunted at birth, was slightly lower, while

the average cognitive functions of children who were not stunted at birth was slightly higher than the average of cognitive function.

Chapter 5

Discussion and Conclusion

This chapter concludes with a discussion of results presented in previous chapters. The limitations and recommendations for further studies are also included.

5.1 Summary of findings

In this study, average cognitive function score is 86.22. Stunted children at aged of 0, 1, 3, 5 and 8.5 years accounted for 7.18%, 12.81%, 24.18%, 21.48% and 21.57%, respectively. Mothers fed their children at aged of 21 days, 3, 6, 12 months by breast feeding only accounted for 50.65%, 47.23%, 50.93% and 45.69%, respectively. Children with low birth weight were found 9.15 % of all children. Cognitive function was statistically significantly associated with maternal education, family income, and stunting at less than one year in age. Children whose mothers attained Bachelor's degree tended to have higher cognitive function than the average. Children from family with the income more than 15,000 Baht per month tended to have higher cognitive function than average, whereas children form family with the income less than 10,000 Baht per month tended to have cognitive function lower than the average. Stunted children at birth tended to have lower cognitive function than the average.

5.2 Discussion

The lower cognitive score than average was found in stunted children at aged less than one year. The result from our finding agrees with a study conducted in Peru and in Philippines. These studies confirmed that stunting at aged 0-2 years is the most

important factor influence cognitive function (Mendez and Adair, 1999 and Berkman *et al*, 2002). Walker *et al*. (2005) found that stunting in early childhood was associated with the cognitive and education deficit in late adolescence. Stunting usually occurs in children age under 2 years and it's affected to delay motor development, poor school performance and poor cognitive function (UNICEF, 2007). Studies conducted by Meehan (2010), Ejekwu *et al*. (2012) and Nanthamongkoichai *et al*. (2004) found that children having a higher education level than their mother tended to have higher cognitive function. The possible explanation is that parent with higher education tend to have higher financial support for their children's education compared to children from less educated parents (Loehlin, 2000).

Children from families with higher incomes tended to have higher cognitive function than those from families with lower income. This result is consistent with a study conducted by To *et al*. (2004), Ejekwu *et al*. (2012) and Sangruang and Plubrukarn (2012). The possible explanation is that poverty is the condition of having not enough income to meet basic needs for food, clothing, and shelter (Chase-Lansdale *et al*, 1995). Poorer children suffer higher incidences of adverse health, developmental, and other outcomes than children who are not affected by poverty (Brooks-Gunn and Duncan, 1997).

In conclusion, improving cognitive function among children should be focused among stunted at age less than 1 year, low educated mother and low income family.

5.3 Limitations and future study

There are some limitations in this study. The information on other factors which may associate with cognitive function such as maternal and paternal IQ were not obtained from this dataset. The sample used in study is from only one district in Songkhla province which may not represent all children in Southern Thailand.

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Appendix

คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยราชภัฏสวนดุสิต
ขอมอบเกียรติบัตรฉบับนี้ไว้เพื่อแสดงว่า

ฟาฏินา สะแม

ได้เข้าร่วมนำเสนอผลงาน การประชุมวิชาการระดับชาติสวนดุสิต : วันนักวิจัยวิทยาศาสตร์ 2013
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List of Publications and Proceedings

Proceedings:

Samae, F. and Lim, A. Demographic and Heath-related Factor Associated with Cognitive Function of Children in Thepa District, Songkla province Southern Thailand. Proceedings of Suan Dusit National Conference: Science Researcher Day 2013. Pp 07-11. Faculty of science and technology, Suan Dusit Rajabhat University.