ปัจจัยที่สัมพันธ์กับความเข้มข้นของไอโอดีนในปัสสาวะหญิงตั้งครรภ์ในประเทศไทย

นายกิตติ ลาภสมบัติศิริ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต

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FACTORS RELATING TO URINARY IODINE CONCENTRATION OF PREGNANT WOMEN IN THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Public Health Program in Heath Systems Development

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กิตติ ลาภสมบัติศิริ : ปัจจัยที่สัมพันธ์กับความเข้มข้นของไอโอดีนในปัสสาวะหญิงตั้งครรภ์ในประเทศไทย. (FACTORS RELATING TO URINARY IODINE CONCENTRATION OF PREGNANT WOMEN IN THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : ROBERT SEDGWICK CHAPMAN, M.D., M.P.H., 71 หน้า.

การศึกษาภาคตัดขวางนี้ศึกษาปัจจัยที่สัมพันธ์กับความเข้มข้นของไอโอดีนในปัสสาวะหญิงตั้งครรภ์ในประเทศไทย กลุ่มตัวอย่างจากโรงพยาบาลรัฐใน8จังหวัดสุ่มเลือกจาก29จังหวัดในระบบเฝ้าระวังการขาดสารไอโอดีนในหญิงตั้งครรภ์ของกระทรวงสาธารณสุขพ.ศ.2548-2550 สุ่มตัวอย่างภาคละ2จังหวัดจาก4ภาคคือ ภาคเหนือ อีสาน กลาง และใต้ แล้วสุ่มตัวอย่างจังหวัดละ100รายได้800ราย ประมาณร้อยละ65(531ราย)ใช้เกลือเสริมไอโอดีนป้องกันการขาดสารไอโอดีน ค่ามัธยฐานความเข้มข้นไอโอดีนในปัสสาวะคือ9.19µg/dl มีหญิงตั้งครรภ์ที่มีความเข้มข้นไอโอดีนในปัสสาวะเหมาะสม(15.00-24.99 µg/dl)เพียงร้อยละ14(112 จาก 800 ราย) ความเข้มข้นไอโอดีนในปัสสาวะต่ำกว่าเกณฑ์ที่เพียงพอ(น้อยกว่า15.00µg/dl)ร้อยละ69.5(556จาก800ราย) ความเข้มข้นไอโอดีนในเกลือจากครัวเรือนทดสอบด้วยอุปกรณ์ไอ-คิทมหาวิทยาลัยมหิดลพบว่าร้อยละ68.1(545จาก 800ตัวอย่างเกลือ)มีไอโอดีน30-100ส่วนใน1ล้านส่วน ในการวิเคราะห์ความสัมพันธ์ของความเข้มข้นไอโอดีนในปัสสาวะกับตัวแปรอิสระในระดับสองตัวแปร ความเข้มข้นไอโอดีนในเกลือและการใช้เกลือเสริมไอโอดีนมีความสัมพันธ์เชิงบวกอย่างมีนัยสำคัญทางสถิติกับความเข้มข้นไอโอดีนในปัสสาวะ($p<0.001$)และมีความแตกต่างอย่างมีนัยสำคัญระหว่างภาคและระหว่างจังหวัดโดยภาคและจังหวัดมีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับความเข้มข้นไอโอดีนในปัสสาวะ($p<0.001$)แต่เมื่อวิเคราะห์ภาคและจังหวัดร่วมกับการใช้เกลือเสริมไอโอดีนและความเข้มข้นไอโอดีนในเกลือโดยการวิเคราะห์ถดถอยเชิงเส้นหลายตัวแปรพบว่ามีเพียงภาคและจังหวัดที่มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับความเข้มข้นไอโอดีนในปัสสาวะ($p<0.001$) ความเข้มข้นไอโอดีนในปัสสาวะหญิงตั้งครรภ์ภาคใต้มีค่าสูงกว่าภาคอื่น ข้อแนะนำจากผลการศึกษานี้คือมาตรการป้องกันการขาดสารไอโอดีนควรได้รับการพิจารณาทบทวนและประยุกต์ให้เหมาะสมกับวัฒนธรรมไทยและวัฒนธรรมท้องถิ่นในแต่ละภาคอย่างมีประสิทธิภาพ กรณีทั่วไปน้ำปลาและอาหารหลายชนิดสามารถผลิตเป็นแหล่งเสริมไอโอดีนของคนไทยได้ อย่างไรก็ตามแหล่งเสริมไอโอดีนสำหรับหญิงตั้งครรภ์ควรมีการศึกษาเพิ่มเติม ข้อมูลจากการศึกษานี้ยังไม่แน่นอนดังนั้นยังจำเป็นต้องมีการวิจัยต่อไปก่อนที่จะมีการเปลี่ยนแปลงนโยบาย การศึกษาต่อไปนั้นความเข้มข้นของไอโอดีนในปัสสาวะหญิงตั้งครรภ์และในปัสสาวะเด็กควรได้รับการประเมินความสัมพันธ์ด้วย.

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KITTI LARPSOMBATSIRI : FACTORS RELATING TO URINARY IODINE CONCENTRATION OF PREGNANT WOMEN IN THAILAND. ADVISOR: ROBERT SEDGWICK CHAPMAN, M.D., M.P.H., 71 pp.

This cross-sectional study was conducted to assess factors relating to urinary iodine concentration (UIC) of pregnant women in Thailand. Subjects were delivered at government hospitals in 8 provinces. These were selected from 29 provinces included in the surveillance system for iodine deficiency in pregnant women of the Ministry of Public Health during 2005-2007. There were 2 provinces from each of the 4 regions of the country i.e. north, northeast, central, and south. There were 800 subjects, 100 from each province. Around 65 percent of them (531 subjects) used iodized salt as iodine deficiency disorders (IDD) prevention measure. Median UIC was 9.19 μg/dl. Only 14% of pregnant women (112 out of 800 subjects) had appropriate UIC (in the range of 15.00 – 24.99 μg/dl). 69.5% of pregnant women (556 out of 800 subjects) had UIC less than adequate level (15 μg/dl). Iodine concentration in household salt was measured by test kit (I-Kit) developed at Mahidol University. 68.1% of household salt samples (545 out of 800 samples) had iodine concentration in the range of 30–100 ppm. Relationships between UIC and independent variables were analyzed. In bivariate analysis, both salt iodine and use of iodized salt for IDD prevention were statistically significantly positively associated with UIC ($p<0.001$). There were also significant differences by region and province. Region and province had statistically significant relationships with UIC ($p<0.001$). However, in multivariable linear regression analysis, only region and province achieved significance ($p<0.001$). UIC was higher in the southern region than in other regions. Study findings suggest that IDD prevention measures in Thailand should be reconsidered. To be effective, these measures should be appropriate to Thai culture and also local cultures of each region of the country. In general, fish sauce and a wide variety of food can be produced to be iodine sources for Thai people. However, appropriate sources of iodine intake for pregnant women should be studied further. The data in this study were subject to uncertainty, so further research is needed before policies are changed. For further study, UIC of pregnant women and UIC of children should also be evaluated for association.

Field of Study:	Health Systems Development	Student's Signature	
Academic Year:	2008	Advisor's Signature	

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LIST OF ABBREVIATIONS

Abbreviations:

DF	Degree of Freedom
FDA	Food and Drug Administration
GLM	General Linear Model
ICCIDD	International Council for Control of Iodine Deficiency Disorders
ICNND	Interdepartmental Committee on Nutrition for National Defense
IDD	Iodine Deficiency Disorders
IQ	Intelligence Quotient
MOPH	Ministry of Public Health
NIDDCP	National Iodine Deficiency Disorders Control Program
PPM	Parts Per Million
TSH	Thyroid Stimulating Hormone
UIC	Urinary Iodine Concentration
UNICEF	United Nations Children’s Fund
USI	Universal Salt Iodization
WHO	World Health Organization
χ^2	Chi-square

CHAPTER I

INTRODUCTION

1.1 Background and Rationale

Iodine is an essential trace element for the synthesis of the thyroid hormones, triiodothyronine(T_3) and thyroxine(T_4). These hormones have important roles for the early growth and development stages of many organs, especially the brain. Iodine can be found naturally in seawater and in marine plants and animals, it is also found in some minerals and in soil. The iodine in soil is leached by repeated flooding, and is carried to the sea. Iodine deficiency can cause a wide range of disorders including endemic goiter, hypothyroidism, cretinism, decreased fertility, miscarriages, stillbirths, congenital anomalies, psychomotor defects, increased perinatal mortality, increased infant mortality, impaired mental function, and mental retardation. Iodine deficiency is the most common preventable cause of mental retardation. Pregnant women who have suffered from iodine deficiency will be affected by the impairment in synthesis of thyroid hormones by themselves and their fetus. Insufficient supply of thyroid hormones to the developing brain can cause mental retardation. By now, there are at least two billion people worldwide have insufficient iodine intake. Although there are a variety of methods to correct iodine deficiency, the most common measure is universal salt iodization (USI), i.e., the addition of suitable amounts of potassium iodide (or iodate) to all salt for human and livestock consumption.

Iodine Deficiency Disorders (IDD) has long been recognized as one of the public health problems in Thailand since 1953 when Dr. Sem Pringpruangkaew reported on “Goiter Belt” along the north and northeast of Thailand.[1] The findings from the first survey by World Health Organization (WHO) consultant Dr.V. Ramalingaswami in 1955 clearly demonstrated that IDD was a major problem in the country.[2] The prevalence of goiter was 58 % in Chiang Mai and Chiang Rai Provinces in the northern region of the country and 15-21 % in Udon Thani and Ubon Ratchathani Provinces in the northeast region of the country. Later, survey by Dr. J.V.Klerk in 1957 confirmed high prevalence of goiter (23% - 45%) in five provinces in the north.[3] The First National Nutrition Survey in 1960 was supported by the Interdepartmental Committee on Nutrition for National Defense (ICNND) from the US government. The survey found that IDD in Thailand had been associated with insufficient iodine intake.[4] There was low quantity of iodine in water and soil, which in turn led to low quantity of iodine in food produced in these areas. In order to increase the iodine intake, the salt iodization program was recommended to the Thai government. The Department of Health, of the Ministry of Public Health, is the main responsible office for implementing intervention programs on IDD alleviation. The pilot project for salt iodization was firstly launched in 1965 in one of the northern districts where goiter prevalence rate had been very high. Later in 1968, salt iodization program was expanded to all affected areas in the country. After five years of salt iodization program, the prevalence of goiter came down substantially. However, the amount of iodized salt produced annually was limited to 20,000 metric tons which was not enough to cover the entire population in affected areas. IDD was included in the 4th and 5th (1977 – 1986) National Social and Economic Development

Plans as one of the priority health issues to be tackled and production and distribution of salt iodization was also set as the main strategy. In 1994, The Ministry of Public Health(MOPH) through the Food and Drug Administration (FDA) issued a Notification on iodized salt (No.153) to enforce iodine fortification to “edible salt” (not include salt for animal consumption and food industry). The concentration of iodine in edible salt must be not less than 30 ppm (parts per million). The household coverage of iodized salt consumption was found to be quite high around that time (78 – 80%).[5] Campaigns for IDD control and prevention has been focusing more on the relationship of IDD and IQ of children. There were findings from research that found the effects of IDD on learning function and work performance.[6] The children who lived in iodine-deficient area might have IQ 10 points lower than the ones who lived in non-iodine-deficient area.[7] Therefore, the National IDD control program was integrated and included in other health promotion activities such as “Health Promoting School”. Goiter prevalence among school children nationwide has been assessed as an indicator to monitor IDD situation. After several years of implementation, goiter prevalence has declined substantially from 19.3 % in 1989 to 1.3 % in 2003 (Figure 1).[8]

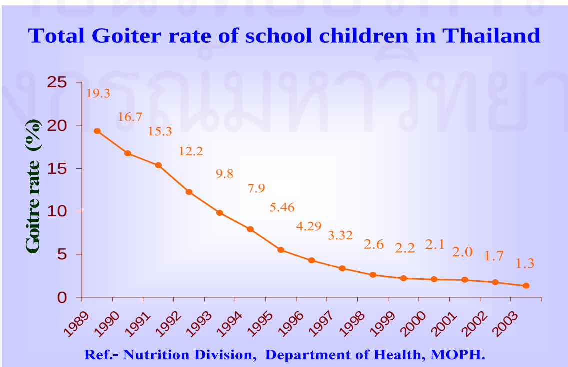


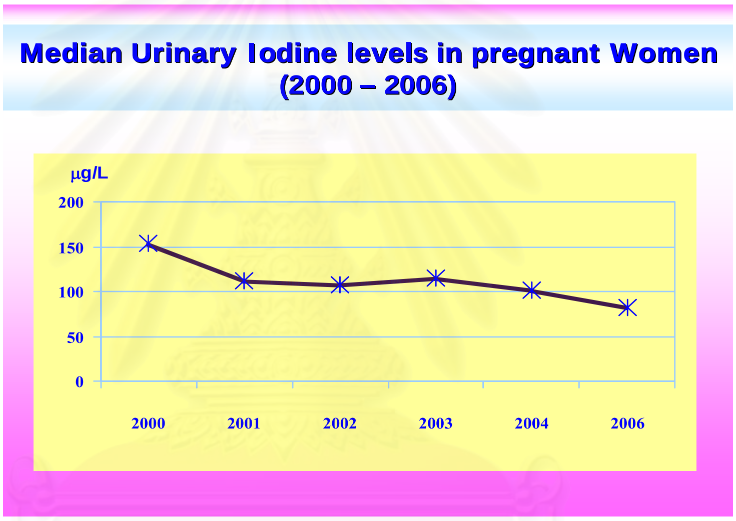
Figure 1 Illustration of total goiter rate of school children in Thailand.

(Department of Health, MOPH, 2006)

Urinary iodine is considered the most sensitive indicator for assessing iodine nutrition status. Urinary iodine levels have been collected from pregnant women each year since 2000. Pregnant women have been selected as target population since they are considered high risk group to become iodine-deficient. Yearly 300 samples of urine are collected from pregnant women from each of the target province (total 15 provinces and 4,500 urine samples) for iodine level determination. Cooking salt has been collected from household of sampled pregnant women to test whether it is qualified iodized salt (≥30 ppm) at the same time of urine collection. The percentage of pregnant women who had urinary iodine concentration less than 10 μg/dl, criteria in the past for iodine deficiency, when compared to the whole was 49.4% and the percentage of pregnant women who had urinary iodine concentration less than 5 μg/dl (moderate and severe iodine-deficient) was 25.5%, according to the Nutrition Division Surveillance System in the year 2004.[9] The percentage of pregnant women who had urinary iodine concentration less than 15 μg/dl, new criteria for iodine deficiency, when compared to the whole was 71.7% and the percentage of pregnant women who had urinary iodine concentration less than 5 μg/dl (moderate and severe iodine-deficient) was 33.9%, according to the Nutrition Division Surveillance System in the year 2006. In the same year, the median urinary iodine concentration (UIC) of pregnant women of the whole country was 8.25 μg/dl. They were 9.25, 6.11, 8.44, and 10.1 μg/dl in the northern, the northeastern, the central, and the southern regions respectively.[10] The adequate level of median UIC of pregnant women group used to be 100-199 μg/L (=10-19.9 μg/dl), according to the WHO/UNICEF/ICCIDD criteria in the past.[11] Recently, the WHO/UNICEF/ICCIDD criteria has been changed to classify the median UIC of 150-249 μg/L (=15-24.9 μg/dl) as the adequate level for the pregnant women group.[12]

The situation of iodine deficiency in Thailand is still in the very serious condition. The awareness of the people with regard to the importance of iodine for brain development should be promoted. Since visible goiter has decreased, some people may not concern that iodine deficiency is a health problem of Thai people, though it really cause more complicated problems. The important reason we conduct this research in the pregnant women is that iodine deficiency can affect IQ. The population in this age group is vulnerable to the effects of iodine deficiency. Consumption of qualified iodized salt is the effective way to prevent iodine deficiency disorders, but the recent information from the Ministry of Public Health showed that household coverage of iodized salt in Thailand was only 63% in 2007.[13] Another problem is whether the salt that pregnant women always consume is qualified iodized salt or not, what about the relationship between the urinary iodine concentration(UIC) of pregnant women and the concentration of iodine in the salt they consume, and what else about the factor(s) relating to the urinary iodine concentration of pregnant women. We plan to do this research because until now there is still a serious condition about the nutritional iodine status of pregnant women in Thailand. Many pregnant women in Thailand still live in the high risk areas of iodine deficiency and have inadequate intake of iodine Furthermore, Thailand is one of the countries that have a large number of salt producers. The interesting point is that IDD problem is still discovered even in the provinces that have at least some part of its border connected to the sea. People in these provinces have more available sources of iodine than those who lived very far from the sea, but the information from the urinary iodine surveillance system showed that there is still the serious condition there. It is necessary to find out any unidentified factor making pregnant women in Thailand vulnerable to the deficiency of iodine.

Current status of median urinary iodine level in pregnant women and coverage of household iodized salt have been shown in Figure 2 and Figure 3 respectively.



*** 2005 : NA**

Figure 2 Illustration of median urinary iodine levels in pregnant women in Thailand. (Nutrition division, Department of Health, MOPH, 2006)

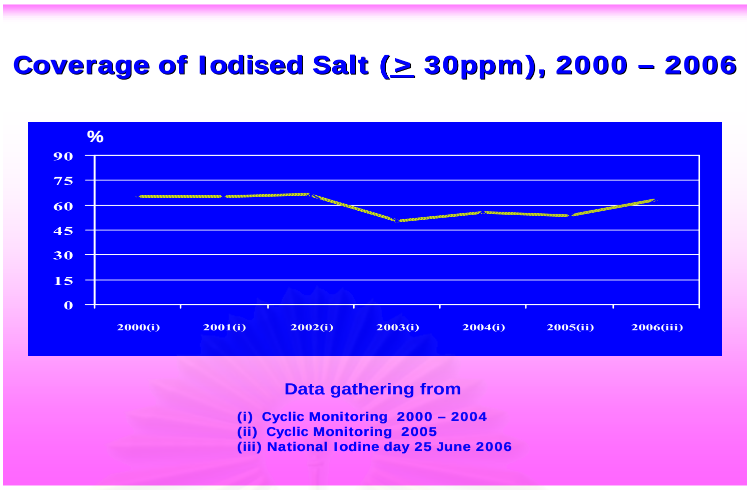


Figure 3 Illustration of coverage of iodized salt in Thailand.

(Ministry of Public Health, 2007)

1.2 Research Questions

1) What is the status of urinary iodine concentration among pregnant women in Thailand?
2) What is the concentration of iodine in salt consumed by pregnant women in Thailand?
3) Is there a relationship between urinary iodine concentration among pregnant women in Thailand and concentration of iodine in salt they consumed?
4) What are the other factors that relate to urinary iodine concentration of pregnant women in Thailand?

1.3 Research Objectives

1.3.1 General Objective

- To explore the factors relating to urinary iodine concentration of pregnant women in Thailand.

1.3.2 Specific Objectives

1) To study the status of urinary iodine concentration among pregnant women in Thailand.
2) To study the iodine concentration of iodine in salt consumed by pregnant women in Thailand.
3) To characterize relationships of urinary iodine concentration with iodine concentration in salt, and with other factors.

1.4 Research Hypothesis

- There is a relationship between urinary iodine concentration among pregnant women in Thailand and iodine concentration in salt they consumed.
- There is a relationship between urinary iodine concentration among pregnant women in Thailand and other factors.

1.5 Conceptual Framework (Figure 4)

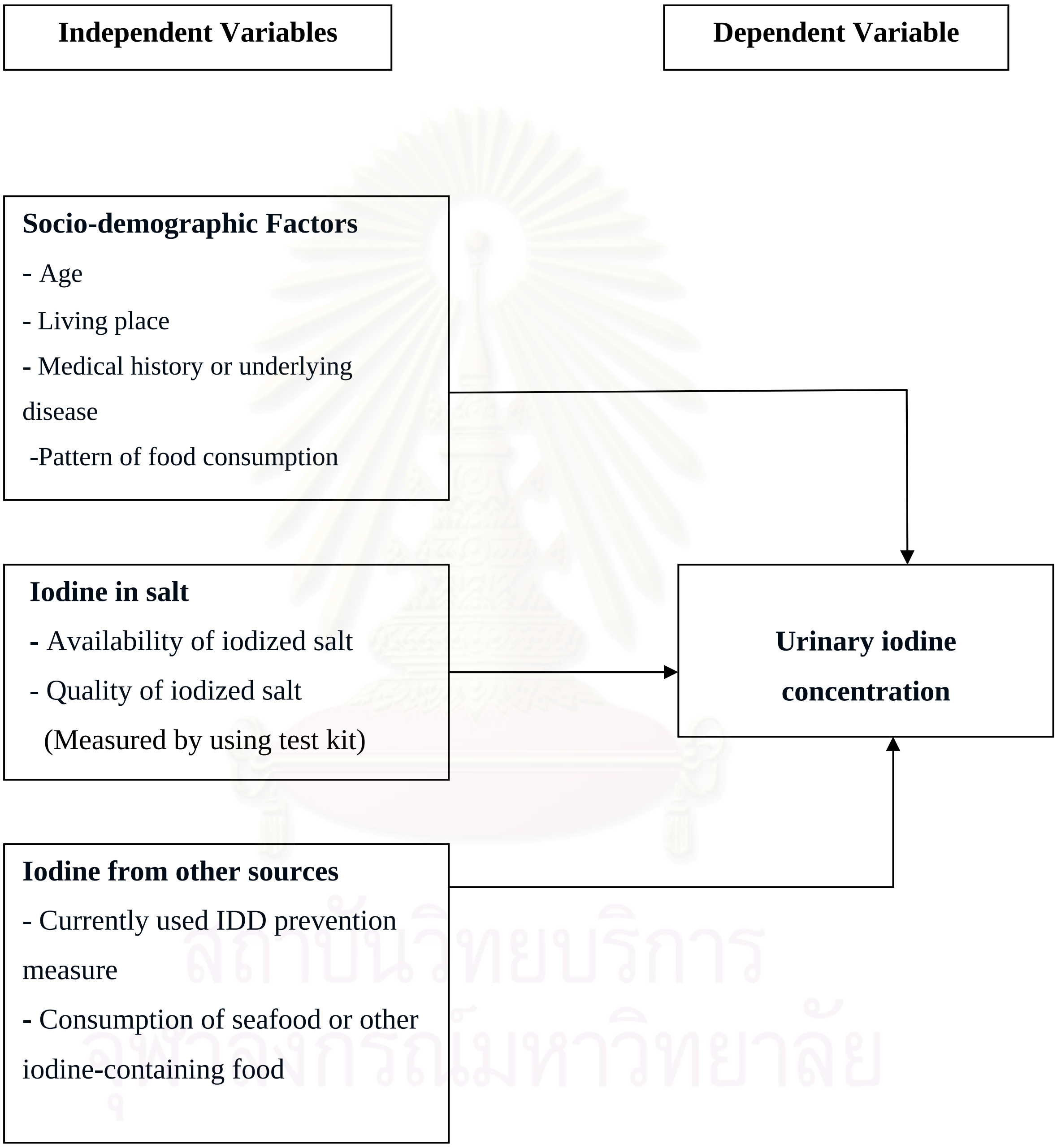


Figure 4 Illustration of conceptual framework

1.6 Operational Definitions

1) Iodized salt – Salt that has been fortified with iodine.

2) Quality of iodized salt – Concentration of iodine in salt ≥30 ppm (parts per million)

3) Living place - The region where pregnant women live around the time of delivery.

4) Medical history – Any known illness or medical condition of pregnant women, especially diseases that involve kidney function and/or are related to hypertension that make them restrict salt consumption.

5) Pattern of food consumption – Type of food and frequency of consumption especially seafood including other iodine-containing food, iodized salt-cooking food, iodized salt-containing food, etc.

6) Availability of iodized salt - The existence of iodized salt in their households including the sources that salt was from (Trademarks of salt, location of salt plants).

7) Currently used IDD prevention measure – Any measure that pregnant women always use around the time of delivery.

8) Urinary iodine concentration (UIC) – The concentration of iodine in spot urine specimen collected from pregnant women near the time of delivery. UIC is classified as < 2, 2-4.99, 5-9.99, 10-14.99, and >15 µg/dl.

CHAPTER II

LITERATURE REVIEW

2.1 Iodine Deficiency Disorders (IDD)

The term iodine deficiency disorders (IDD) refers to all the effects of iodine deficiency on growth and development in a human and animal population, which can be prevented by correction of the iodine deficiency. These include goiter, stillbirths, neonatal and other types of hypothyroidism but the most important effect is that of fetal brain damage. The relation between iodine deficiency and brain damage was originally raised by observations of the association of goiter and mental retardation (endemic cretinism).[14] The at risk population for IDD was estimated in 1990 by WHO to be 1.6 billion including in excess of 20 million with some degree of brain damage due to the effects of iodine deficiency in pregnancy. Iodine is considered the most common preventable cause of brain.[15] More recently, these estimates have been increased to 2.2 billion at risk of the effects of iodine deficiency.[16] Iodine deficiency results in a global loss of 10-15 IQ points at a population level.[17]

2.2 Nutritional Iodine Status during Pregnancy

Physiologic adaptation of the thyroidal economy associated with normal pregnancy is replaced by pathologic changes when a pregnancy takes place in conditions with iodine deficiency or even only mild iodine restriction. Globally, the changes in maternal thyroid function that occur during gestation can be viewed as a mathematical fraction, with hormone requirements in the numerator and the availability of iodine in the denominator. When availability of iodine becomes deficient during gestation, at a time when thyroid hormone requirements are increased, this situation presents an additional challenge to the maternal thyroid. In 2001, the World Health Organization officially endorsed recommendations made by international organizations such as the ICCIDD (International Council for Control of Iodine Deficiency Disorders) and UNICEF (United Nations Children's Fund) to eliminate iodine deficiency disorders, on the basis that iodine deficiency present at critical stages during pregnancy and early childhood resulted in impaired development of the brain and consequently in impaired mental function. Although a variety of methods exists for the correction of iodine deficiency, the most commonly accepted and applied method is universal salt iodization (USI), i.e., the addition of suitable amounts of potassium iodide (or iodate) to all salt for human and livestock consumption.

Table 1. Recommended iodine intake during pregnancy and lactation

Population Group	**Recommended Iodine intake**
Pregnant women	250 μg/d
Lactating women	250 μg/d

(WHO/UNICEF/ICCIDD 2007)

Table 2. Iodine nutrition adequacy based on urinary iodine excretion

Population Group	**Median Urinary Iodine conc.**	**Category of Iodine intake**
Pregnant women	< 150 μg/L	Insufficient
	150 – 249 μg/L	Adequate
	250 – 499 μg/L	More than adequate
	> 500 μg/L	Excessive
Lactating women	< 100 μg/L	Insufficient
	> 100 μg/L	Adequate

(WHO/UNICEF/ICCIDD 2007)

2.3 Iodine Deficiency Disorders in Thailand

Iodine Deficiency Disorders (IDD) has long been recognized as one of the public health problems in Thailand since 1953 when Dr. Sem Pringpruangkaew reported on "Goiter Belt" along the north and northeast of Thailand.[1] The pilot project for salt iodization was firstly launched in 1965 in one of the northern districts where goiter prevalence rate had been very high. Later in 1968, salt iodization program was expanded to all affected areas in the country. After five years of salt iodization program, the prevalence of goiter came down substantially. After several years of implementation, goiter prevalence has declined substantially (from 19.3 % in 1989 to 1.3 % in 2003.[8] Urinary iodine is considered the most sensitive indicator for assessing iodine nutrition status. Urinary iodine levels have been collected from pregnant women each year since 2000. Pregnant women have been selected as target population since they are considered high risk group to become iodine deficiency.

Yearly 300 samples of urine are collected from pregnant women from each of the target province (total 15 provinces and 4,500 urine samples) for iodine level determination. Cooking salt has been collected from household of sampled pregnant women to test whether it is qualified iodized salt (≥30 ppm) at the same time of urine collection. The median urinary iodine level of pregnant women of the whole country was 8.25 μg/dl in the year 2006 (They were 9.25, 6.11, 8.44, and 10.1 μg/dl in the North, the Northeast, the Central, and the South region respectively.). The percentage of pregnant women who had urinary iodine concentration less than 15 μg/dl when compared to the whole was 71.7%(iodine-deficient) and the percentage of pregnant women who had urinary iodine concentration less than 5 μg/dl was 33.9%(moderate and severe iodine-deficient).[10] The iodine concentration of salt at the production level should be between 50 ppm and 80 ppm and, at the consumption level, not less than 30 ppm. These are based on an average daily salt intake of 7.5 grams per person, and assumed for a loss of 50% from production to consumption. That was recommended by MOPH, UNICEF, and ICCIDD.[18] The recent information showed that household coverage of iodized salt in Thailand is only 63% in 2007 (Ministry of Public Health, 2007).[10] The percentage of households consuming effectively iodized salt (iodine concentration of salt ≥ 30 ppm for Thailand) for more than 90% has been used as one of the core indicators in tracking progress towards the goal of eliminating IDD as a significant public health problem. That was recommended by WHO, UNICEF, and ICCIDD.[11] The recent percentage of households consuming effectively iodized salt was still far less than the recommended level.

2.4 Iodine Deficiency Disorders Prevention and Control in Thailand

Salt iodization has been the main strategy in Thailand since 1968. The Ministry of Public Health through the Food and Drug Administration (FDA) issued a Notification on iodized salt (No.153) to enforce iodine fortification to "edible salt" (not include salt for animal consumption and food industry). During the beginning period of National Iodine Deficiency Disorders Control Program(NIDDCP) (1991 – 1995) there was advocacy campaigns of IDD goiter and IQ. The coverage of household iodized salt consumption was found to be quite high (78 – 80%).[5] Another strategy is water iodization. The Department of Health has encouraged the people in remote areas to add 2 drops of concentrated iodine solution (packed in 30 cc bottle) to 10 liters of drinking water converting it to iodized drinking water. This measure was adopted from the late Professor Romsai Suwannik, who invented it.[19] Other food items such as fish sauce and instant noodle which are widely consumed by Thai people are also fortified with iodine and iron in fish sauce, while instant noodle is fortified with iodine, iron and vitamin A. Currently, instant noodles are widely available in the market but fish sauce is available only in limited amount. Efforts are on to make it commercially available.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Study Design

The study design for this thesis was a descriptive and analytical cross-sectional study concerning the factors relating to urinary iodine concentration of pregnant women in Thailand. The data were secondary data from a study already conducted by MOPH of Thailand. The Nutrition Division was responsible for the entire project of this MOPH study. Official permission from the Director of the Nutrition Division, Department of Health, MOPH has been given for my thesis to take place. The MOPH study is described below. Then study procedures for this thesis are described. To date, the MOPH data have been analyzed only at the province level. My MPH thesis analyzed data at the level of the individual subject.

3.2 MOPH Study

- **Study area**

The study areas were the government hospitals in 29 provinces in Thailand: Tak, Phrae, Mae Hong Son, Nong Khai, Chaiyaphum, Maha Sarakham, Yasothon, Mukdahan, Songkhla, Ranong, Trang, Chai Nat, Nakhon Pathom, Phetchaburi, Lampang, Phichit, Nakhon Sawan, Phitsanulok, Kalasin, Khon Kaen, Buri Ram, Udon Thani, Satun, Phuket, Phang Nga, Lop Buri, Rayong, Nonthaburi, Sa Kaeo provinces in Thailand.

- **Study population**

The population in this study was pregnant women who were delivered at the government hospitals in these 29 provinces.

- **Study period**

October 2005 - September 2007

- **Sampling technique**

Systematic sampling method was used to determine the study provinces. All 75 provinces of Thailand were sorted by the iodine deficiency prevalence rate in descending order. The first province in the series and also every fifth province following the first province were selected to study in the fiscal year 2006. This technique was also used during the fiscal years 2007-2010 by selecting the second, the third, the fourth, and the fifth province in the series respectively and every fifth province following them. There were 14 provinces in the study period October 2005-September 2006 and 15 provinces in the study period October 2006-September 2007 (It was previously expected to have 15 provinces in the study period October 2005-September 2006, but there were some undisclosed problems for receiving the data from the other one province.). All of the government hospitals in these provinces were included for the study. Then quota sampling method was employed, pregnant women who were delivered at government hospitals compatible with inclusion criteria and without exclusion criteria were recruited in the study during the period of data collection until the number of subjects reached 300 for each province.

Inclusion criteria: Pregnant women who were delivered at government hospitals who were willing to participate in the interview by using questionnaires.

Exclusion criteria: 1) Pregnant women who lived outside the province

2) Pregnant women who declined to participate in the study or the hospital where they were delivered did not take part in the study

3) Pregnant women who lived in Bangkok.

In general, every pregnant women who met the inclusion criteria without exclusion criteria from all government hospitals in any study province during the period of time expected that 300 subjects could be recruited for each province.

- **Measurements made**

1) Urinary iodine concentration was tested by Sandell-Kolthoff Reaction Method . The results of the test were interpreted in the unit of microgram per deciliter (μg/dl). So, this variable was a continuous variable. Urine specimens (10-20 milliliter for each specimen) were collected from the subjects just before delivery when they were in the labor room or just after delivery. Timing for collecting urine was set as above to make it easier for the staff of all hospitals participating in the study to collect urine specimens at the same trimester of pregnancy that was usually the end of the third trimester.

2) The iodine concentration of salt was measured by test kit (I-Kit, developed at Mahidol University). The results of the test were interpreted in the unit of parts per million (ppm). There were 5 levels of the result shown on the test kit (0, 10, 30, 50, and 100 ppm). The iodine concentrations between test kit levels could also be reported. Salt was brought from the subject's home in the delivery day or a few days after delivery.

3) The data were collected by standardized questionnaires. In the standardized questionnaires, the subjects were interviewed about the following information:

- Socio-demographic characteristics such as age, address, currently used IDD prevention measure, underlying disease and consumption of seafood or any other iodine-containing food.
- Availability of iodized salt and source of salt they currently consumed.

- **Data collection**

- The researchers submitted the formal letter to the Provincial Health Officers in the study provinces.
- The researchers communicated with the staff of health care professionals to collect data, test for iodine concentration in salt, and collect urine specimen.
- Before data collection, information and objectives of this study were described to the subjects. Hospital informed consent was obtained from each subject.
- Primary data were collected by face to face interview. All subjects were asked the same questions.

3.3 Thesis Study Procedures

- **Study period for the thesis**

  September 2008 - May 2009

- **Sample size calculation**

  Sample size is calculated by the following formula:

$$n = \frac{z^2_{\alpha/2}\, p\,(1-p)}{d^2}$$

n= minimum sample size

α= level of statistical significance = 0.05

$z^2_{\alpha/2}$ = 2-sided critical value for 95% confidence level = 1.96

d = error allowance = 0.05

p = expected proportion of population whose UIC less than 10 μg/dl

= 0.49 (MOPH,2003-2004)

1-p = 1-0.49 = 0.51

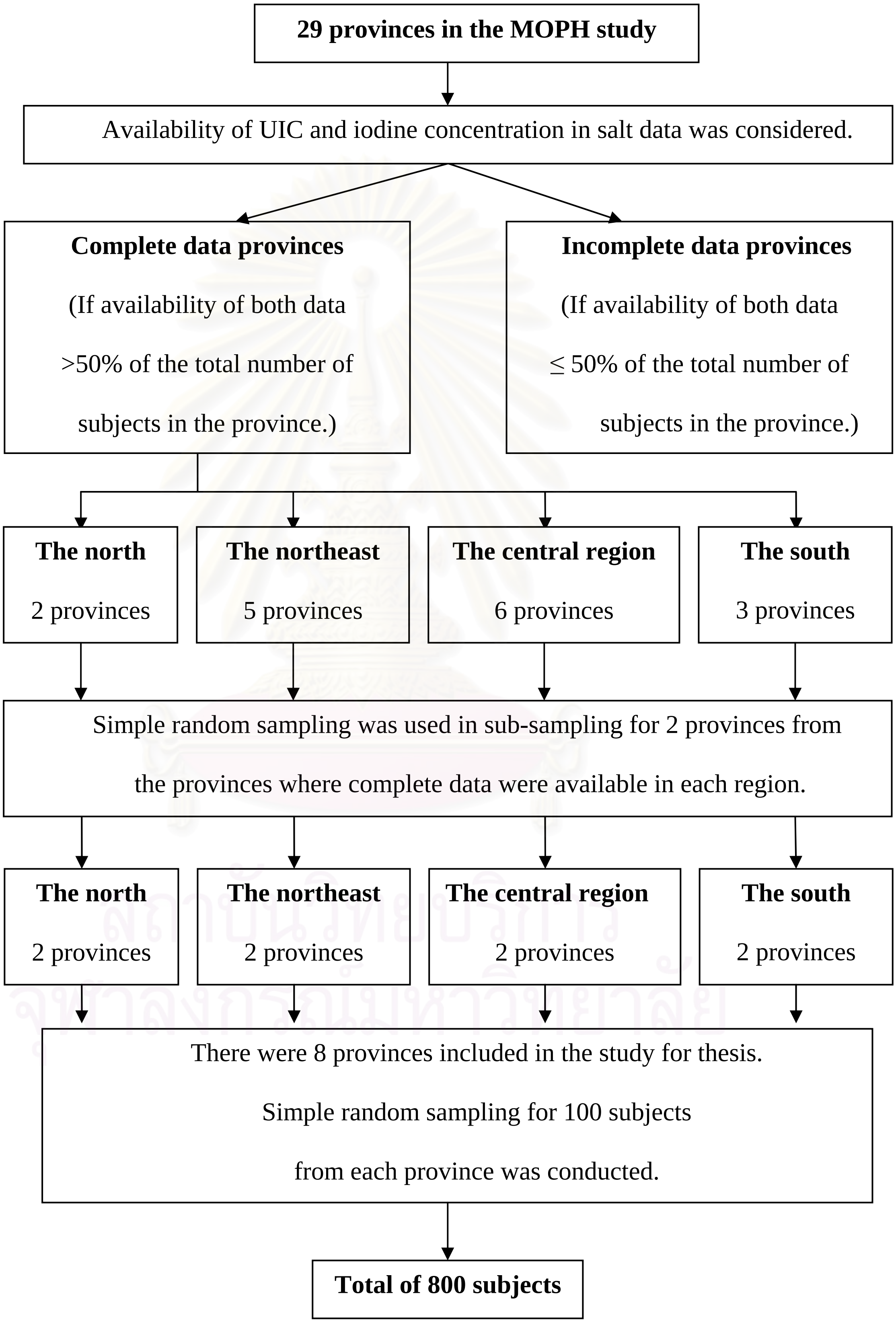
$$n = \frac{(1.96)^2(0.49 * 0.51)}{(0.05)^2}$$

= 384.01 (Minimum sample size = 385)

- **Sub-sampling for thesis**

According to the data about urinary iodine concentration and iodine concentration in salt, there were incomplete data in some provinces. These 29 provinces were separated into 2 groups in all 4 regions: acceptable complete data and incomplete data groups. The acceptable complete data group was defined by availability of both data about urinary iodine concentration and iodine concentration in salt more than 50% of the total number of subjects. Simple random sampling was used in sub-sampling for 2 provinces from the provinces where the acceptable complete data were available in each region (The total number of provinces in the acceptable complete data group in each region: 2 provinces from the northern region, 5 provinces from the northeastern region, 3 provinces from the southern region, and 6 provinces from the central region.). After this process, there were 8 provinces (2 provinces from each region) included in the study for thesis. Then simple random sampling for 100 subjects from each province, all of whom have data on urinary iodine concentration and iodine concentration in salt, was conducted. So, there were totally 800 subjects, many more than the required sample size. The process of sub-sampling are shown in Figure 5.

Figure 5 Illustration of sub-sampling for thesis



- **Data analysis**

The researchers coded the questionnaires before entering the data to the computer. For data analysis, statistical software was used.

Descriptive statistics –. Frequency, percentage, median, mean and standard deviation were used to describe the characteristics measured in this study.

Inferential statistics were used to identify relationships between urinary iodine concentration of pregnant women (dependent variable) and the independent variables. In bivariate analysis, urinary iodine concentration variable was analyzed with other variables such as age group of the pregnant women, province, region of the country, location of residence (Mueang district or outside Mueang district), current use of iodized salt as IDD prevention, iodine concentration in household salt, and consumption of seafood or other iodine-containing food. Chi-square test was used to study about relationship between 2 categorical variables. In case of non-normal distribution of urinary iodine concentrations, non-parametric Kruskal-Wallis test and Mann-Whitney test were also used and the results were compared with the results of Chi-square test. The dependent variable (urinary iodine concentration) was analyzed as a categorical variable in chi-square test, but it was analyzed as a continuous variable in non-parametric Kruskal-Wallis test and Mann-Whitney test. Then, the results from these tests could be considered together to see what they expressed were similar or different. If they provided the same things, we could have more confidence in conclusion of the results. Spearman’s correlation (non-parametric) and linear regression analysis were used to characterize the relationship between the urinary iodine concentration of pregnant women and the iodine concentration in salt they consumed. These techniques were also used to characterize the relationships of urinary iodine concentration of pregnant women with the other independent variables.

Any variables that showed p-value less than 0.20 in bivariate analysis with urinary iodine concentration were included in multivariable models using linear regression (general linear models (GLM) routine of SPSS). Urinary iodine concentration variable was included in multivariable analysis as a dependent variable. Independent variables were treated as fixed factors (nominal categorical variables) or covariates (continuous variables or ordinal variables with several levels). In some cases, ordinal variables were treated as covariates and factors in different models.

3.4 Ethical Consideration

-The pregnant women who participated in this study were admitted for delivery service in hospital. The participants were informed formally about the hospital services that they were going to involve. The participants were explained about the purpose of the study. The participants' information was kept confidentially.

-Actually, there was no specific informed consent for the study of urinary iodine concentration. However, all pregnant women who got delivery services in hospital normally were already willing to sign informed consent for hospital services. And this study involved the collection of urine for determining the urinary iodine concentration that was one of the hospital services, the participants were informed to understand these processes and objectives before interview and collection of urine specimens. No name or street address was entered in the electronic data file.

CHAPTER IV

RESULTS

The objective of this research was to study the status of urinary iodine concentration among pregnant women in Thailand, the iodine concentration of iodine in salt they consumed, and also explore the factors relating to urinary iodine concentration of pregnant women in Thailand including the relationships of urinary iodine concentration with iodine concentration in salt.

Secondary data from Nutrition Division, Department of Health, Ministry of Public Health of Thailand were used in this research. According to the surveillance system for iodine deficiency disorders in the pregnancy group in Thailand during the fiscal year 2006 and 2007 (October 2005 – September 2007) covering 29 provinces from 4 regions of the country (north, northeast, central, and south), sub-sampling for thesis was conducted and the results from 800 pregnant women (There were 8 provinces included in the research by simple random sampling; 2 provinces from each of the 4 regions i.e. Phrae and Lampang from the northern region, Nong Khai and Maha Sarakham from the northeastern region, Phetchaburi and Nonthaburi from the central region, and Trang and Satun from the southern region, the subjects were randomly selected for 100 cases from each province.) were analyzed by SPSS.

4.1 Descriptive Information

According to Table 3, the results from the study of 800 pregnant women found that the majority of subjects were between 20 and 29 years of age. There was 14.9%

of these pregnant women who were in the age group of younger than 20 years old, 26.2% was in the age group of 20– 24 years old, 28.5% was in the age group of 25–29 years old, 17.9% was in the age group of 30– 34 years old and 12.5% was older than 35 years old. Mean age of the study subjects was 26.51 years old, the standard deviation was 6.37, the minimum and maximum were 14 and 47 years old respectively. The subjects lived in Phrae and Lampang provinces in the north, Nong Khai and Maha Sarakham provinces in the northeast, Phetchaburi and Nonthaburi provinces in the central region, Trang, and Satun provinces in the south and were also delivered at the government hospitals in these 8 provinces. Each 12.5% of the total study subjects was randomly selected from each province. These 8 provinces were separated into 4 regions of the country equally, so there was 25.0% of the total study subjects in each region (north, northeast, central, and south). The location of residence in Table 3 focused on whether the subjects lived in Mueang district or not. The research result found that 29.4 % of the total study subjects lived in Mueang district and 70.6 % lived outside Mueang district. The location of residence in each province provided the percentage of the total study subjects who lived and attended the ANC clinic at the government hospitals in each province: 2.5% and 10.0% from Mueang district and outside Mueang district in Nong Khai province respectively, 1.8% and 10.8% from Mueang district and outside Mueang district in Phetchaburi province respectively, 4.0% and 8.5% from Mueang district and outside Mueang district in Maha Sarakham province respectively, 3.2% and 9.2% from Mueang district and outside Mueang district in Phrae province respectively, 5.0% and 7.5% from Mueang district and outside Mueang district in Trang province respectively, 4.1% and 8.4% from Mueang district and outside Mueang district in Nonthaburi province respectively, 3.5% and 9.0% from Mueang district and outside Mueang district in Lampang province respectively, 5.2% and 7.2% from Mueang district and outside Mueang district in Satun province respectively.

Table 3 Subject characteristics

Characteristics	**Frequencies (n = 800)**	**Percentage**
Age (yr)		
< 20	119	14.9
20 – 24	210	26.2
25 – 29	228	28.5
30 – 34	143	17.9
≥ 35	100	12.5
Mean = 26.51 SD = 6.37		
Minimum = 14 Maximum = 47		
Median = 26.00		
Region		
North	200	25.0
Northeast	200	25.0
Central	200	25.0
South	200	25.0

Table 3 (continued) Subject characteristics

Characteristics	Frequencies (n = 800)	Percentage
Province		
Phrae	100	12.5
Lampang	100	12.5
Nong Khai	100	12.5
Maha Sarakham	100	12.5
Phetchaburi	100	12.5
Nonthaburi	100	12.5
Trang	100	12.5
Satun	100	12.5
Location of residence		
Mueang District	235	29.4
Outside Mueang District	565	70.6
Location of residence in each province		
North		
Phrae (Mueang District)	26	3.2
Phrae (Outside Mueang District)	74	9.2
Lampang (Mueang District)	28	3.5
Lampang (Outside Mueang District)	72	9.0

Table 3 (continued) Subject characteristics

Characteristics	Frequencies (n = 800)	Percentage
Northeast		
Nong Khai (Mueang District)	20	2.5
Nong Khai (Outside Mueang District)	80	10.0
Maha Sarakham (Mueang District)	32	4.0
Maha Sarakham (Outside Mueang District)	68	8.5
Central		
Phetchaburi (Mueang District)	14	1.8
Phetchaburi (Outside Mueang District)	86	10.8
Nonthaburi (Mueang District)	33	4.1
Nonthaburi (Outside Mueang District)	67	8.4
South		
Trang (Mueang District)	40	5.0
Trang (Outside Mueang District)	60	7.5
Satun (Mueang District)	42	5.2
Satun (Outside Mueang District)	58	7.2
Underlying disease		
Any disease	25	3.1
None	733	91.6
Missing	42	5.2

Table 3 (continued) Subject characteristics

Characteristics	**Frequencies (n = 800)**	**Percentage**
Current use of measures to prevent iodine deficiency disorders (detailed)		
None	159	19.9
Iodized salt	524	65.5
Iodinated water	9	1.1
Thyroid medication	1	0.1
Iodized salt + Iodinated water	6	0.8
Iodized salt + Thyroid medication	1	0.1
Missing	100	12.5
Current use of IDD prevention measures*		
None	159	19.7
Iodized salt	531	65.8
Iodinated water	15	1.9
Thyroid medication	2	0.2
Missing	100	12.4

Table 3 (continued) Subject characteristics

Characteristics	Frequencies (n = 800)	Percentage
Iodine concentration in household salt (ppm)		
0 – 9	178	22.2
10 – 29	77	9.6
30 – 49	242	30.2
50 – 100	303	37.9
Consumption of seafood or other iodine-containing food in past week		
No	102	12.8
Yes	582	72.8
Missing	116	14.5

Table 3 (continued) Subject characteristics

Characteristics	**Frequencies (n = 800)**	**Percentage**
Urinary iodine concentration collected near time of delivery (µg/dl)		
< 2.00	106	13.2
2.00 – 4.99	130	16.2
5.00 – 9.99	182	22.8
10.00 – 14.99	138	17.2
15.00 – 24.99	112	14.0
≥ 25.00	132	16.5
Median = 9.19		
Minimum = 0.00 Maximum = 897.00		
Mean = 19.61 SD = 5.23		

* Adds to 807 because subjects could choose >1 item.

There were 25 pregnant women in this research who had some underlying diseases, but the percentage of this group was only 3.1% of the total study subjects. Thalassemia and goiter were 2 groups of the most common diseases among these subjects. There were 5 cases of Thalassemia (0.63%) and 5 cases of goiter (0.63%).

About the measures for IDD prevention, there were 700 pregnant women who answered the multiple response question about their current use of IDD prevention measures, there was no answer found in the questionnaires of the other 100 pregnant women. When we looked into the details of the answers, the results showed that there was 19.9% of the total number of study subjects did not use any measure for IDD prevention, 65.5% used only iodized salt, 1.1% used only iodinated water, 0.1% used only thyroid medication, 0.8% used both iodized salt and iodinated water, and 0.1% used both iodized salt and thyroid medication. On the other hand, when compared to the total number of the answers to this multiple response question combined with the subjects who had no answer (the total number is 807 occasions), 19.7% of them did not use any measure for IDD prevention, 65.8% used iodized salt, 1.86% used iodinated water, 0.25% used thyroid medication. The pregnant women who were recruited in the MOPH study were supposed to take their household salt to the hospital near time of delivery or they might have their relatives take the salt to the hospital a few days after delivery. The iodine concentration in salt was measured by test kit (I-Kit, developed by Mahidol University). The results of iodine concentration in salt collected from household showed that 22.2% of the total collected salt had iodine concentration in the range of 0 – 9 ppm, 9.6% had iodine concentration in the range of 10 – 29 ppm, 30.2% had iodine concentration in the range of 30 – 49 ppm, and 37.9% had iodine concentration in the range of 50 – 100 ppm.

The results about consumption of seafood or other iodine-containing food in past week showed that 12.8% had not consumed seafood or other iodine-containing food in past week, 72.8% had consumed seafood or other iodine-containing food in past week, and 14.5% had no answer.

The urine of pregnant women was collected just before delivery when they were in the labor room or just after delivery. Iodine concentrations in urine specimens were tested by Sandell-Kolthoff Method. The results of iodine concentrations in urine specimens collected near time of delivery and their classifications by WHO/UNICEF/ICCIDD2001 criteria showed that 13.2% had UIC less than 2.00 μg/dl which was classified as severe iodine deficiency, 16.2% had UIC in the range of 2.00 – 4.99 μg/dl, which was classified as moderate iodine deficiency, 22.8% had UIC in the range of 5.00 – 9.99 μg/dl, which was classified as mild iodine deficiency, 17.2% had UIC in the range of 10.00 – 14.99 μg/dl, which was also classified as mild iodine deficiency, 14.0% had UIC in the range of 15.00 – 24.99 μg/dl, which was classified as adequate urinary iodine, and 16.5% had UIC in the level of 25 or more. Median UIC of the study subjects was 9.19 μg/dl, the minimum and maximum were 0.00 and 897.00 μg/dl respectively. Median UIC of pregnant women in the north, the northeast, the central , and the south region were 12.22, 4.50, 8.99, and 12.24 μg/dl respectively.

4.2 Analytical Results

Urinary iodine concentration variable is a continuous variable with non-normal distribution. Thus, the relationships of urinary iodine concentration of pregnant women with iodine concentration in their household salt and other factors were analyzed by non-parametric Kruskal-Wallis test, Mann-Whitney test for categorical independent variables, and Spearman's correlation for continuous independent variables. Chi-square test was used to determine the association between two categorical variables. So, when the data of urinary iodine concentration were categorized into the ordinal scale, we used Chi-square test to determine the association between UIC category and the factors we were studying. We used combination of. Chi-square test and Kruskal-Wallis test or Chi-square test and Mann-

Whitney test to compare the results of each other. Any variables that showed p-value less than 0.20 were taken into multivariable analysis using linear regression (general linear models (GLM) routine of SPSS).

Bivariate analysis

According to Tables 4 and 12, the results showed no significant relationship between age group and urinary iodine concentration of pregnant women (p>0.05).

Table 4 Age group and urinary iodine concentration of pregnant women

Age (yr)	**Number (Percentage) by urinary iodine concentration in μg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
< 20	15	21	23	21	18	21	119	χ^2
	(12.6)	(17.6)	(19.3)	(17.6)	(15.1)	(17.6)	(100)	9.280
20 – 24	30	31	48	37	31	33	210	20 d.f.
	(14.3)	(14.8)	(22.9)	(17.6)	(14.8)	(15.7)	(100)	p = 0.979
25 – 29	28	42	55	43	27	33	228	
	(12.3)	(18.4)	(24.1)	(18.9)	(11.8)	(14.5)	(100)	
30 – 34	18	21	32	24	18	30	143	
	(12.6)	(14.7)	(22.4)	(16.8)	(12.6)	(21.0)	(100)	
≥ 35	15	15	24	13	18	15	100	
	(15.0)	(15.0)	(24.0)	(13.0)	(18.0)	(15.0)	(100)	
Total	106	130	182	138	112	132	800	
	(13.2)	(16.2)	(22.8)	(17.2)	(14.0)	(16.5)	(100)	

Province and region of the country (north, northeast, central, and south) where pregnant women lived had significant relationships with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 5, Table 6, and Table 12.

Location of residence in Mueang district or outside Mueang district had no significant relationship with urinary iodine concentration of pregnant women ($p>0.05$) as shown in Table 7 and Table 13.

The information of current use of IDD prevention was collected, only 700 subjects had responded to this question in questionnaires used for the surveillance system for iodine deficiency disorders in the pregnancy group in Thailand. Only current use of iodized salt as IDD prevention was analyzed to find the relationship with urinary iodine concentration of pregnant women. The result showed that there was significant relationship between current use of iodized salt as IDD prevention and urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 8 and Table 13. The subjects in the group of using iodized salt as a prevention measure for IDD also had significantly higher iodine concentration in salt than those who did not use iodized salt as a prevention measure ($p<0.001$) as shown in Table 9. Iodine concentration in household salt of the study subjects also had significant relationship with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 10 and Table 12.

According to Table 11 and Table 13, Consumption of seafood or iodine-containing food in past week had no significant relationship with urinary iodine concentration of pregnant women.

Table 5 Province and urinary iodine concentration of pregnant women

Province	Number (Percentage) by urinary iodine concentration in µg/dl							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
Nong Khai	42	18	21	8	4	7	100	χ^2
	(42.0)	(18.0)	(21.0)	(8.0)	(4.0)	(7.0)	(100)	218.1
Phetchaburi	13	27	22	13	15	10	100	35 d.f.
	(13.0)	(27.0)	(22.0)	(13.0)	(15.0)	(10.0)	(100)	$p < 0.001$
Maha	25	19	29	15	10	2	100	
Sarakham	(25.0)	(19.0)	(29.0)	(15.0)	(10.0)	(2.0)	(100)	
Phrae	7	12	28	19	14	20	100	
	(7.0)	(12.0)	(28.0)	(19.0)	(14.0)	(20.0)	(100)	
Trang	10	22	27	16	14	11	100	
	(10.0)	(22.0)	(27.0)	(16.0)	(14.0)	(11.0)	(100)	
Nonthaburi	5	16	24	25	14	16	100	
	(5.0)	(16.0)	(24.0)	(25.0)	(14.0)	(16.0)	(100)	
Lampang	3	10	19	23	17	28	100	
	(3.0)	(10.0)	(19.0)	(23.0)	(17.0)	(28.0)	(100)	
Satun	1	6	12	19	24	38	100	
	(1.0)	(6.0)	(12.0)	(19.0)	(24.0)	(38.0)	(100)	
Total	106	130	182	138	112	132	800	
	(13.2)	(16.2)	(22.8)	(17.2)	(14.0)	(16.5)	(100)	

Table 6 Region and urinary iodine concentration of pregnant women

Region	**Number (Percentage) by urinary iodine concentration in µg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
North	10	22	47	42	31	48	200	χ^2
	(5.0)	(11.0)	(23.5)	(21.0)	(15.5)	(24.0)	(100)	143.7
Northeast	67	37	50	23	14	9	200	15 d.f.
	(33.5)	(18.5)	(25.0)	(11.5)	(7.0)	(4.5)	(100)	$p<0.001$
Central	18	43	46	38	29	26	200	
	(9.0)	(21.5)	(23.0)	(19.0)	(14.5)	(13.0)	(100)	
South	11	28	39	35	38	49	200	
	(5.5)	(14.0)	(19.5)	(17.5)	(19.0)	(24.5)	(100)	
Total	106	130	182	138	112	132	800	
	(13.2)	(16.2)	(22.8)	(17.2)	(14.0)	(16.5)	(100)	

Table 7 Location and urinary iodine concentration of pregnant women

Location	**Number (Percentage) by urinary iodine concentration in μg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
Mueang district	24 (10.2)	45 (19.1)	61 (26.0)	36 (15.3)	33 (14.0)	36 (15.3)	235 (100)	χ^2 6.543
Outside Mueang district	82 (14.5)	85 (15.0)	121 (21.4)	102 (18.1)	79 (14.0)	96 (17.0)	565 (100)	5 d.f. p=0.257
Total	106 (13.2)	130 (16.2)	182 (22.8)	138 (17.2)	112 (14.0)	132 (16.5)	800 (100)	

Table 8 Current use of iodized salt as IDD prevention measure and urinary iodine concentration of pregnant women

Current use of iodized salt as IDD prevention	**Number (Percentage) by urinary iodine concentration in µg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
Yes	59	89	118	86	83	96	531	χ^2
	(11.1)	(16.8)	(22.2)	(16.2)	(15.6)	(18.1)	(100)	32.217
No	43	31	41	27	13	14	169	5 d.f.
	(25.4)	(18.3)	(24.3)	(16.0)	(7.7)	(8.3)	(100)	p<0.001
Total	102	120	159	113	96	110	700	
	(14.6)	(17.1)	(22.7)	(16.1)	(13.7)	(15.7)	(100)	

Table 9 Current use of iodized salt as IDD prevention measure and iodine concentration in household salt

Current use of iodized salt as IDD prevention	**Number (Percentage) by iodine concentration in household salt in parts per million (ppm)**					
	0-9	**10-29**	**30-49**	**50-100**	**Total**	
Yes	72	49	179	231	531	χ^2
	(13.6)	(9.2)	(33.7)	(43.5)	(100)	118.9
No	89	18	35	27	169	3 d.f.
	(52.7)	(10.7)	(20.7)	(16.0)	(100)	$p<0.001$
Total	161	67	214	258	700	
	(100)	(100)	(100)	(100)	(100)	

Table 10 Iodine concentration in household salt and urinary iodine concentration of pregnant women

Iodine in salt (ppm)	**Number (Percentage) by urinary iodine concentration in μg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
0-9	44	35	46	24	15	14	178	χ^2
	(24.7)	(19.7)	(25.8)	(13.5)	(8.4)	(7.9)	(100)	56.536
10-29	16	8	16	14	9	14	77	15 d.f.
	(20.8)	(10.4)	(20.8)	(18.2)	(11.7)	(18.2)	(100)	p<0.001
30-49	18	45	57	43	35	44	242	
	(7.4)	(18.6)	(23.6)	(17.8)	(14.5)	(18.2)	(100)	
50-100	28	42	63	57	53	60	303	
	(9.2)	(13.9)	(20.8)	(18.8)	(17.5)	(19.8)	(100)	
Total	106	130	182	138	112	132	800	
	(13.2)	(16.2)	(22.8)	(17.2)	(14.0)	(16.5)	(100)	

Table 11 Consumption of seafood or iodine-containing food in past week and urinary iodine concentration of pregnant women

Consumption of seafood or iodine-containing food	**Number (Percentage) by urinary iodine concentration in µg/dl**							
	< 2.00	**2.00-4.99**	**5.00-9.99**	**10.00-14.99**	**15.00-24.99**	**≥ 25.00**	**Total**	
Yes	83	103	126	94	85	91	582	χ^2
	(14.3)	(17.7)	(21.6)	(16.2)	(14.6)	(15.6)	(100)	1.741
No	14	16	22	16	13	21	102	5 d.f.
	(13.7)	(15.7)	(21.6)	(15.7)	(12.7)	(20.6)	(100)	p=0.884
Total	97	119	148	110	98	112	684	
	(14.2)	(17.4)	(21.6)	(16.1)	(14.3)	(16.4)	(100)	

Table 12 Relationships between UIC and subject characteristics (province, region, iodine concentration in household salt , and age group)

	N	Mean Rank	Kruskal-Wallis		
			Chi-square	**d.f.**	**p-value**
Province					
Nong Khai	100	233.86	165.998	7	<0.001
Phetchaburi	100	351.96			
Maha Sarakham	100	283.12			
Phrae	100	442.02			
Trang	100	378.84			
Nonthaburi	100	435.90			
Lampang	100	501.42			
Satun	100	576.88			
Region					
North	200	471.72	117.101	3	<0.001
Northeast	200	258.49			
Central	200	393.93			
South	200	477.86			

Table 12 (continued) Relationships between UIC and subject characteristics (province, region, iodine concentration in household salt , and age group)

	N	Mean Rank	Kruskal-Wallis		
			Chi-square	**d.f.**	**p-value**
Iodine concentration in household salt (ppm)					
0.00 – 9.00	178	299.51	46.819	3	<0.001
10.00 – 29.00	77	395.98			
30.00 – 49.00	242	421.74			
50.00 – 100.00	303	444.02			
Age group (yr)					
< 20	119	403.73	2.028	4	0.731
20 – 24	210	397.14			
25 – 29	228	389.08			
30 – 34	143	423.23			
≥ 35	100	397.26			

Table 13 Relationships between UIC and subject characteristics (location, iodized salt used as IDD prevention, consumption of seafood or other iodine-containing food, and underlying disease)

	N	**Mean Rank**	**Mann-Whitney U**	
			Z	**p-value**
Location in province (n=800)				
Mueang district	235	393.25	-0.572	0.567
Outside Mueang district	565	403.51		
Iodized salt used as IDD prevention (n=700)				
No (not use as IDD prevention)	169	277.75	-5.370	<0.001
Yes	531	373.65		
Consumption of seafood or other iodine-containing food (n=684)				
No	102	357.11	-0.810	0.418
Yes	582	339.94		
Underlying disease (n=758)				
Yes	25	362.84	-0.387	0.699
No	733	380.07		

Table 14 Spearman's correlations of UIC of pregnant women with age and iodine concentration in household salt

Factors	Correlation coefficient	p-value
Age	0.011	0.759
Iodine concentration in household salt	0.189	<0.001

Spearman's correlations of UIC with age and iodine concentration in household salt are shown in Table 14. Age of pregnant women did not have significant correlation with UIC ($p > 0.05$). Iodine concentration in household salt had significant positive correlation with UIC ($p < 0.001$).

Multivariable analysis

Any variables that showed p-value < 0.20 in bivariate analysis were included in multivariable analysis using linear regression (general linear models routine of SPSS). Urinary iodine level was the dependent variable. The independent variables for which p-value less than 0.20 in the analysis of relationships with urinary iodine concentration of pregnant women were the province where they lived ($p<0.001$), the region of the country where they lived ($p<0.001$), the iodine concentration in their household salt ($p<0.001$), the use of iodized salt as a prevention measure for IDD ($p<0.001$). Iodine concentration in household salt had positive relationship to urinary iodine concentration, the higher urinary iodine concentration could be found in pregnant women whose household salt contained higher iodine concentration. Pregnant women who answered that they used iodized as IDD Prevention also had higher urinary iodine concentration than pregnant women who answered they did not.

These significant factors were compared to test for the relationships with urinary iodine concentration of pregnant women simultaneously to see which factors still had significant relationships with urinary iodine concentration of pregnant women. Province and region could not be included in the same multivariable model, because these 2 variables were completely correlated.

As we had seen the result from analysis of current use of iodized salt as IDD prevention and UIC by Chi-square test and Mann-Whitney test, we found that there was significant relationship of current use of iodized salt as IDD prevention with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 8 and Table 13. In addition, as we had seen the result from analysis of iodine concentration in household salt and UIC by Chi-square test and Kruskal-Wallis test, we found that iodine concentration in household salt of the study subjects also had significant relationship with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 10 and Table 12. Spearman's correlation of UIC with iodine concentration in household salt also showed significant correlation ($p<0.001$) as shown in Table 14. However, when the data were analyzed using linear regression (general linear models (GLM) routine of SPSS) by examining the relationships of region of the country, current use of iodized salt as IDD prevention, and iodine concentration in household salt of the study subjects simultaneously, the result showed that only region of the country had significant relationship with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Tables 15.1 and 15.2. In Table 15.1, we considered region variable and iodine concentration in salt variable as fixed factors, current use of iodized salt as IDD prevention variable as a covariate, but in Table 15.2, only region variable was considered as a fixed factor, iodine concentration in salt variable and current use of iodized salt as IDD prevention variable were considered as covariates.

Furthermore, when the data were analyzed using linear regression (general linear models (GLM) routine of SPSS) by examining the relationships of province, current use of iodized salt as IDD prevention, and iodine concentration in household salt of the study subjects simultaneously, the result showed that only province had significant relationship with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Tables 15.3 and 15.4. In Table 15.3, we considered province variable and iodine concentration in salt variable as fixed factors, current use of iodized salt as IDD prevention variable as a covariate, but in Table 15.4, only province variable was considered as a fixed factor, iodine concentration in salt variable and current use of iodized salt as IDD prevention variable were considered as covariates.

The province and region variables were analyzed separately because the region variable was transformed from the province variable, there must be a relationship between these two variables and the results of analysis may be interfered by this relationship. In summary; in multivariable analysis, only the province and region of the country were the only independent variables that had statistically significant relationships with urinary iodine concentrations ($p<0.001$).

The results from Table 15.1 and Table 15.2 also showed that pregnant women in the southern region of Thailand had higher urinary iodine concentrations than pregnant women in the other regions. However, the results from Table 15.3 and Table 15.4 showed that in the southern region of Thailand, there was substantial difference between urinary iodine concentrations of pregnant women in Trang and Satun provinces. As we knew that iodine can be found naturally in seawater and in marine plants and animals, it is also found in some minerals and in soil. The iodine in soil was leached by repeated flooding, and was carried to the sea. This may be the reason why pregnant women in the southern region of Thailand had higher urinary iodine concentrations than pregnant women in the other regions of the country. According to the difference between urinary iodine concentrations of pregnant women in Trang and Satun provinces, it may be the effect of high variations in the level of urinary iodine concentrations. However, both Trang and Satun provinces are located in the southern region of Thailand and pregnant women in these two provinces had higher urinary iodine concentrations than pregnant women in the other regions of the country.

Table 15.1 Multivariable analysis 1 (Dependent variable: UIC)

Parameter	**Coefficient**	**95% confidence interval**	**p-value**
Region (fixed factor)			<0.001
North	-20.572	-33.890 to -7.613	0.002
Northeast	-24.818	-38.537 to -11.099	<0.001
Central	-24.674	-36.458 to -12.889	<0.001
South	0		
Iodine concentration in salt (ppm) (fixed factor)			0.370
0.00 – 9.00	-7.829	-21.516 to 5.859	0.262
10.00 – 29.00	-4.690	-20.085 to 10.705	0.550
30.00 – 49.00	-9.138	-19.797 to 1.521	0.093
50.00 – 100.00	0		
Current use of iodized salt as IDD prevention (covariate)	3.819	-7.280 to 14.918	0.500

Table 15.2 Multivariable analysis 2 (Dependent variable: UIC)

Parameter	**Coefficient**	**95% confidence interval**	**p-value**
Region (Fixed factor)			<0.001
North	-18.233	-30.788 to -5.678	0.004
Northeast	-21.479	-34.219 to -8.740	0.001
Central	-22.213	-33.423 to -11.002	<0.001
South	0		
Iodine concentration in salt (ppm) (covariate)	2.646	-1.805 to 7.096	0.244
Current use of iodized salt as IDD prevention (covariate)	3.696	-7.381 to 14.773	0.513

Table 15.3 Multivariable analysis 3 (Dependent variable: UIC)

Parameter	**Coefficient**	**95% confidence interval**	**p-value**
Province (fixed factor)			<0.001
North			
Phrae	-33.313	-50.136 to -16.489	<0.001
Lampang	-27.302	-45.697 to -8.907	0.004
Northeast			
Nong Khai	-32.480	-49.899 to -15.061	<0.001
Maha Sarakham	-34.459	-51.305 to -17.613	<0.001
Central			
Phetchaburi	-39.061	-54.401 to -23.720	<0.001
Nonthaburi	-27.214	-43.315 to -11.114	0.001
South			
Trang	-27.281	-45.237 to -9.326	0.003
Satun	0		
Iodine concentration in salt (ppm) (fixed factor)			0.540
0.00 – 9.00	-9.591	-23.531 to 4.349	0.177
10.00 – 29.00	-7.981	-23.761 to 7.799	0.321
30.00 – 49.00	-0.912	-12.841 to 11.017	0.881
50.00 – 100.00	0		
Current use of iodized salt as IDD prevention (covariate)	0.378	-11.178 to 11.933	0.949

Table 15.4 Multivariable analysis 4 (Dependent variable: UIC)

Parameter	**Coefficient**	**95% confidence interval**	**p-value**
Province (Fixed factor)			<0.001
North			
Phrae	-33.423	-50.167 to -16.678	<0.001
Lampang	-27.019	-45.337 to -8.700	0.004
Northeast			
Nong Khai	-32.937	-50.189 to -15.685	<0.001
Maha Sarakham	-34.572	-51.249 to -17.894	<0.001
Central			
Phetchaburi	-38.549	-53.717 to -23.381	<0.001
Nonthaburi	-27.979	-43.739 to -12.220	0.001
South			
Trang	-25.398	-41.260 to -9.535	0.002
Satun	0		
Iodine concentration in salt (ppm) (covariate)	3.222	-1.316 to 7.760	0.164
Current use of iodized salt as IDD prevention (covariate)	0.579	-10.870 to 12.028	0.921

CHAPTER V

DISCUSSION AND RECOMMENDATIONS

5.1 Discussion

Iodine deficiency is the most common preventable cause of mental retardation. Iodine deficiency during pregnancy and early childhood stages can result in impaired development of the brain and consequently in impaired mental function of children. The most commonly accepted and applied method to prevent iodine deficiency is salt iodization. In Thailand, iodized salt has long been used as the principal measure to prevent and control iodine deficiency. The surveillance systems of iodine deficiency in pregnant women usually use urinary iodine concentration as an indicator because it is sensitive; 90% of ingested iodine is excreted in 24-hour urine[19]. The objectives of this research were to characterize, among pregnant women in Thailand, the status of urinary iodine concentration, the iodine concentration in salt consumed, and the relationships of urinary iodine concentration with iodine concentration in salt, and with other factors.

This descriptive and analytical cross-sectional study involved 800 pregnant women who were delivered at the government hospitals in 8 provinces. There were 100 participants from each of the 8 provinces. Secondary data from Nutrition Division, Department of Health, Ministry of Public Health of Thailand was used in this research. Sub-sampling from the Nutrition Division data was done by simple random sampling. Eight provinces were taken into the study by simple random sampling of 2 provinces from 4 regions of the country i.e. north, northeast, central, and south. Then simple random sampling for 100 subjects from each province was conducted. These subjects were drawn only from the provinces for which more than 50% of subjects had both urinary and salt iodine measurement.

Frequency, percentage, median, mean, and standard deviation were used for data description. Urinary iodine concentration was not normally distributed. Thus, bivariate analysis of associations between the dependent variable, urinary iodine concentration, and independent variables was conducted using non-parametric tests. Specifically, these were the chi-square test, Mann-Whitney test, Kruskal-Wallis test, and Spearman's correlation. Linear regression analysis (GLM routine in SPSS) was used to assess multivariable associations between independent and dependent variables. The majority of subjects were between 20 and 29 years of age. Mean age of the study subjects was 26.51 years old, the standard deviation was 6.37, the minimum and maximum were 14 and 47 years old respectively. The subjects lived in Phrae and Lampang provinces in the north, Nong Khai and Maha Sarakham provinces in the northeast, Phetchaburi and Nonthaburi provinces in the central region, Trang, and Satun provinces in the south and were also delivered at the government hospitals in these 8 provinces. Around 65 percent of the study subjects used iodized salt as IDD prevention measure.

My thesis study used secondary data from the surveillance system for "Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand" in the second round beginning in the fiscal year 2006. The data from the surveillance system for "Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand" during 2000 – 2004, that was in the first round, were not used for my thesis because no raw data could be found. However, there were some comparisons between the results of my thesis study and the results from reports of the first and second rounds of MOPH study in terms of urinary iodine concentration and iodine concentration in salt.

Median urinary iodine concentration of the study subjects was 9.19 μg/dl (Median was used to describe the data of urinary iodine concentrations because the data had non-normal distribution and there were substantial numbers of outliers in the data set.). In the MOPH study, they were 8.25 μg/dl and 10.82 μg/dl in the years 2006 and 2007 respectively.[20] These results showed that pregnant women in Thailand still face iodine deficiency problem (WHO/UNICEF/ICCIDD criteria classified median UIC of pregnant women <15 μg/dl as insufficient iodine intake.).[12] The results of median urinary iodine concentration from the surveillance system for "Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand" during 2000 – 2004 were 15.3, 11.16, 10.68, 11.45, and 10.16 μg/dl respectively.[9] These results showed no apparent improvement of the iodine nutrition status of pregnant women in Thailand. In this study, there were pregnant women who had appropriate urinary iodine concentration (urinary iodine concentration in the range of 15.00 – 24.99 μg/dl) only 14.0%. Most pregnant women still had urinary iodine concentration less than adequate level (556 out of 800 subjects, 69.5%). The percentage of pregnant women who had urinary iodine concentration less than adequate level (urinary iodine concentration < 15 μg/dl) in this study was somewhat similar to the percentages in the MOPH study in the year 2006 and 2007 (They were 71.7% and 61.2% respectively.). The percentages of pregnant women who had urinary iodine concentration less than 15 μg/dl from the surveillance system for “Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand” during 2000 – 2004 (the first round) were not available because the cut-off point the MOPH used at that time was the urinary iodine concentration of 10 µg/dl. Thus, the report of the first round did not show results of urinary iodine concentration using cut-off point at 15 µg/dl and the raw data were not available at the time my thesis took place. In that case, it was difficult to make a comparison with the first round. The percentage of pregnant women who had urinary iodine concentration less than 10 µg/dl in this study was 52.3% (418 out of 800 subjects), that approximated to the percentages in the MOPH study in the year 2006 and 2007 (They were 57.4% and 46.9% respectively.). The results of the percentages of pregnant women who had urinary iodine concentration less than 10 µg/dl from the surveillance system for “Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand” during 2000 – 2004 (the first round) were 34.5%, 45.1%, 47.0%, 44.5%, and 49.3% respectively. These results showed that there was no apparent improvement in the iodine nutrition status of pregnant women in Thailand.

The iodine concentration in salt was measured by test kit (I-Kit, developed at Mahidol University). The results of iodine concentration in salt collected from household showed that 22.2% of the total collected salt had iodine concentration in the range of 0 – 9 ppm, 9.6% had iodine concentration in the range of 10 – 29 ppm, 30.2% had iodine concentration in the range of 30 – 49 ppm, and 37.9% had iodine concentration in the range of 50 – 100 ppm. The percentage of the study subjects whose household salt contained iodine ≥ 30 ppm was 68.1% (545 out of 800 salt specimens). The percentage of households consuming effectively iodized salt (iodine concentration of salt ≥ 30 ppm for Thailand) for more than 90% has been used as one of the core indicators in tracking progress towards the goal of eliminating IDD as a significant public health problem (WHO, UNICEF, ICCIDD, 1994)[11]. The percentage of households consuming effectively iodized salt in this study was still far less than the recommended level, so was the percentage of households consuming effectively iodized salt in the MOPH study in 2007 (63%).[13] The results of iodine concentration in salt from the surveillance system for "Tracking Progress towards the Sustainable Elimination of Iodine Deficiency Disorders in Thailand" during 2000 – 2004 also showed quite similar situation. The percentages of households consuming effectively iodized salt were 65.3%, 65.5%, 66.8%, 50.6%, and 56.1% respectively.

In bivariate analysis, province and region of the country (the north, northeast, central, and south) where pregnant women lived had significant relationships with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 5, Table 6, and Table 12. There was significant relationship between current use of iodized salt as IDD prevention and with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Table 8 and Table 13. Iodine concentration in household salt of the study subjects also had significant relationship with urinary iodine concentration of pregnant women ($p<0.001$) as shown in Tables 10 and 12.

However, when these variables were considered in multivariable analysis, only region and province were statistically significantly associated with urinary iodine concentration ($p<0.001$), as shown in Tables 15.1-15.4. Specifically, urinary iodine concentration was significantly higher in the south than in other regions, and was higher in the southern provinces Satun and Trang than in other provinces. Even so, urinary iodine concentration was significantly higher in Satun than in Trang (Tables 15.3 and 15.4).

These observations may be related to the fact that the southern provinces were close to the sea, and that iodine is abundant in seawater and in marine plants and animals. It is also found in some minerals and in soil. The iodine in soil can be leached by repeated flooding, and carried to the sea. That may be the reason why people who live in the area near the sea have less possibility to be affected by iodine deficiency. Another reason may be the difference in use of seasonings among different regions. In the southern region, the most common sodium chloride-containing seasoning added in food was salt. On the other hand, the most common sodium chloride-containing seasoning added in food for all of the other regions was fish sauce.[21] In Thailand, there are only a few fish sauce producers fortifying their products with iodine. The number of iodized salt producers was much more than the number of fish sauce producers who fortified their products with iodine.[22]. However, there was substantial difference between urinary iodine concentrations of pregnant women in Trang and Satun provinces, it may be the effect of high variations in the level of urinary iodine concentrations. In Satun province, very high urinary iodine levels were seen in some pregnant women especially the one who had urinary iodine level so high as 897 μg/dl, that was the upper limit in the range of urinary iodine levels of all subjects in the study. The extraordinarily high urinary iodine level like this, which was not found in Trang province, somewhat affected the overall picture of urinary iodine levels in the study subjects and resulted in difference between these two provinces.

Study findings also suggest that iodine concentration in salt had some relationships to region of the country and province. Although the result of bivariate analysis between iodine concentration in salt and urinary iodine concentration of pregnant women showed significant relationship, that could be the effect of other factors such as region of the country and province where they lived, which were the only two variables found to have statistically significant relationships to urinary iodine concentration. In this study, we cannot conclude that current use of iodized salt is an effective prevention measure against IDD for pregnant women. Furthermore, iodized salt may not be the ideal measure for providing iodine in the specific group like pregnant women, because of the need to limit salt intake during pregnancy period. Nowadays, in some European countries, iodine has been given to pregnant women and breast-feeding mothers by taking multivitamin tablets containing iodine in order to reach the recommended daily iodine intake.[23] And this may be one of the appropriate alternatives that can protect pregnant women against IDD.

Different cultures and lifestyles among people in different countries should be considered when we study about iodized salt, there is a variety of patterns of salt consumption among people in different countries or even in the same country. Furthermore, people in some places do not use salt as seasoning at all. In case of salt consumption, most Thai people usually use salt for cooking food, only some people add it into food as table salt, so we cannot know exactly about the amount of iodine that has decreased with high temperature while the salt were used in cooking.

Limitations of the study

There were some limitations in the study about iodized salt consumption among the subjects. The existence of iodized salt in households does not mean that people really consume that salt, and we cannot be sure whether they consume it regularly or not. Furthermore, we do not know the exact time period of using iodized salt for IDD prevention before the subjects were recruited. Substantial numbers of missing data were found. However, the subjects in the group of using iodized salt as a prevention measure for IDD had significantly higher iodine concentration in salt than those who did not use iodized salt as a prevention measure ($p<0.001$) as shown in Table 9. .The exact time period of seafood or other iodine-containing food consumption was another lack of information. This variable also had substantial numbers of missing data (116 out of 800 subjects, 14.5%). It should be considered carefully about the results of the thesis involving the consumption of seafood or other iodine-containing food. The results showed no significant relationship between consumption of seafood or other iodine-containing food and urinary iodine concentration of the subjects ($p>0.05$). Further research concerning the more detail information of time period of both iodized salt consumption and seafood or other iodine-containing food consumption should be conducted with the attempt to reduce the number of missing data.

Variation in interpretation of the test for iodine concentration in salt is another source of uncertainty. Method of the test for iodine concentration in salt (I-Kit) used in this study can result in different levels from different readers. This kind of equipment was commonly used in the field study which required time and budget savings. Therefore, the scale of results from this equipment may have a little bit difference from the result from the equipment used for determining the iodine concentration in salt in the high-technology laboratory units.

Extremely high levels of urinary iodine concentration obtained from laboratory unit sometimes may not express the real iodine concentration in urine, there may be contamination from any external source. This study used secondary data from the Ministry of Public Health (MOPH). The original MOPH study was conducted in many provinces, and it needed collaboration with staff in many hospitals. There could be contamination of iodine from external sources of iodine in the processes from collection of the urine specimens on the way to laboratory unit . Unfortunately, there are only a few laboratory units in Thailand that can perform determination of iodine concentration in urine. Thus, there was often a time lag between urine specimen collection and urinary iodine measurement. This could also introduce error in the reported urinary iodine concentrations.

Benefits of the study

The result of the study showed apparently that region of the country and province were the factors relating to urinary iodine concentration of pregnant women in Thailand. Neither current use of iodized salt as iodine deficiency prevention measure nor iodine concentration in household salt was directly and significantly related to urinary iodine concentration. This information justifies re-examination of Thailand's policies regarding IDD prevention in pregnant women and their babies. It also justifies ascertainment of the most effective means to achieve IDD prevention.

5.2 Recommendations

Recommendations from findings of this study: In multivariable analysis, only the province and region of the country were the only independent variables that had statistically significant relationships with urinary iodine concentrations ($p<0.001$).

Pregnant women in the southern region of Thailand had higher urinary iodine concentrations than pregnant women in the other regions. Efforts should be made to clarify the differences between people lived in the southern region and those who lived in the other regions of Thailand. The important sources of iodine for people from the south should be identified and these might be applied appropriately to the cultures and lifestyles of people from the other regions. Besides sources of iodine, there are still a lot of determinants especially accessibility to health information and individual health seeking behaviors that may be the causes of the difference in urinary iodine concentrations between pregnant women who lived in the south and those who lived in the other regions. Salt iodine concentration and current use of iodized salt for IDD prevention lost statistical significance in multivariable analysis although they showed very high statistical significance in bivariate analysis. .the concerned agency should revise the appropriateness of using iodized salt as principal measure for prevention and control of iodine deficiency disorders. It should be applied appropriately to Thai culture. Fish sauce can be fortified with iodine and used as one of the iodine sources for Thai people. Besides, there is still a wide variety of food that we can fortify with iodine. This will provide Thai people with more choices of iodine intake. Nationwide campaign on the importance of regular iodine intake should also be intensified especially in the regions of the country that there is still more vulnerable condition of iodine deficiency. Every effort should be made to disseminate information and knowledge to people, to raise public awareness of the deleterious effects of iodine deficiency on health especially brain development and IQ of children, and to provide alternative sources of iodine to consume sufficiently.

Recommendations for further study: Further research that employ standardized methods and thorough quality control is still needed before making policy choices on control and prevention of IDD. A time lag between urine specimen collection and urinary iodine measurement could introduce error in the reported urinary iodine concentrations. In case of examination for iodine concentration in salt, the scale of results from the equipment in this study may have somewhat difference from the result from the equipment used for determining the iodine concentration in salt in the high-technology laboratory units. Improvement in quality control and technical accuracy will reduce uncertainties of data.

Urinary iodine concentration of pregnant women and neonatal thyroid stimulating hormone (TSH) should be evaluated for association in the further study. That will provide more accurate evaluation of iodine nutrition status of both pregnant women and their children. Moreover, further research on urinary iodine concentration of children will make us understand more about the magnitude of IDD problem and how we can manage this problem effectively. Appropriate sources of iodine-containing food that can be applied appropriately to lifestyles and cultures of Thai people especially in pregnant women should also be studied.

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APPENDICES

APPENDIX A: Questionnaires (English version)

Hospital……………………………………………District…………………………….Province……………………………………

*   Underlying disease 1 = None, 2 = Goiter, 3 =Mental retardation, 4 =Thyrotoxicosis, 5 = Others (please specify……...............................……)

**   Currently used IDD prevention measure 1 =None, 2 =Iodinated water, 3 =Iodine supplement capsule, 4 =Thyroid medication, 5 = Iodized salt

*** Source of salt or its trademark or Location of salt plant

****Consumption of seafood or other iodine-containing food in the past week (None =0, or please specify the name of food you consumed.)

Code No.	Name, surname	Age	Address			Date of collection		Underlying disease*	IDD prevention measure**	Iodine concentration		Source of salt or trademark***	Seafood /iodine-containing food****
			House No.	Group	Sub-district	Urine	Salt			Salt ppm	Urine µg/L		

APPENDIX B: Questionnaires (Thai version)

แบบเก็บข้อมูล

โรงพยาบาล..อำเภอ..จังหวัด..

* โรคประจำตัว 1 = ไม่มี, 2 = คอพอก, 3 = ปัญญาอ่อน(เอ๋อ), 4 = คอพอกเป็นพิษ, 5 = อื่นๆ ระบุ ....

** มาตรการป้องกันโรคขาดสารไอโอดีน 1 = ไม่ได้รับ, 2 = น้ำเสริมไอโอดีน, 3 = ไอโอดีนแคปซูล, 4 = ยารักษาไทรอยด์, 5 = เกลือเสริมไอโอดีน

*** ยี่ห้อเกลือ แหล่งที่มา เช่น ยี่ห้ออะไร โรงงานผลิตอยู่ที่ไหน

**** การได้รับประทานอาหารทะเลหรืออาหารที่เสริมไอโอดีน ในรอบ 1 สัปดาห์ที่ผ่านมา ถ้าไม่ได้รับประทานให้ใส่ 0, ถ้ารับประทาน ให้ระบุชื่ออาหาร

รหัส จว.-รพ.-No.	ชื่อ-นามสกุล (ไม่ต้องใส่คำนำหน้า-นาง)	อายุ	ที่อยู่			วันเดือนปี ที่เก็บ		โรคประจำตัว*	การป้องกัน IDD**	ปริมาณไอโอดีน		ยี่ห้อเกลือ แหล่งที่มา***	อาหารทะเล/ อาหารที่มี ไอโอดีน****
			บ้านเลขที่	หมู่ที่	ตำบล	ปัสสาวะ	เกลือ			ในเกลือ	ในปัสสาวะ		

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