IODINE STATUS AMONG PREGNANT WOMEN IN KELANTAN

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ENDORSEMENT

The project report entitled **Iodine status among pregnant women in Kelantan** by **Nur Zezadila Binti Mohamed Zainuzain**, Matric No. **UK 17614** has been reviewed and corrections have been made according to the recommendations by examiners. This report is submitted to the Department of Food Science in partial fulfillment of the requirement of the degree of Bachelor of Food Science (Food Service and Nutrition), Faculty of Agrotechnology, Universiti Malaysia Terengganu.

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(DR. HAYATI MOHD YUSOF)

Main supervisor

Date: 8/2/2012

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRACT

The present study was carried out to determine the iodine status among pregnant women in Kelantan. 100 respondents with age between 16 and 42 were participated in this study. The mean age for this study population is 29.39 (SD=5.73). Questionnaire was used to obtain socio-demographic information, obstetric data, knowledge on iodine and IDDs, knowledge, practise and attitude towards iodized salt and also dietary data. Anthropometry measurement of height and weight were taken. The mean height of the respondents is 153.72 (SD=10.41) while the mean weight is 67.75 (SD=15.69). Determination urinary iodine was performed by using modified micromethod of Sandell-Kolthoff Rection. Median urinary iodine of the respondents showed severe insufficiency, which is 8.5 µg/L. Correlation test showed that there is a significant relationship between socio-economic status and urinary iodine concentration (r = -0. 251, $p < 0.05$). Besides, there are no significant relationship between dietary intake and urinary iodine concentration. As a conclusion, reassessment and monitoring of iodine nutritional status is important even in populations that are apparently considered not at risk of iodine deficiency, especially in pregnant women. Regular administration of iodine, starting at preconception or in early pregnancy and continuing during the period of nursing, is recommended. Health education also should be given to promote adequate iodine intake, as pregnant women are particularly vulnerable to inadequate dietary iodine intake.

ABSTRAK

STATUS IODIN DI KALANGAN WANITA MENGANDUNG DI KELANTAN

Kajian ini telah djalankan untuk menentukan status iodin di kalangan wanita mengandung. Seramai 100 responden yang berumur di antara 16 dan 42 telah menyertai kajian ini. Min umur bagi populasi kajian ini ialah 29.39 (SD=5.73). Kaedah borang soal-selidik telah digunakan untuk mendapatkan maklumat mengenai latar belakang, data obstetrik, pengetahuan terhadap iodin dan penyakit disebabkan kekurangan iodine, pengetahuan, amalan dan sikap terhadap penggunaan garam beriodin dan juga data mengenai pengambilan makanan. Pengukuran antropometri seperti tinggi dan berat juga diambil. Min tinggi bagi responden ialah 153.72 (SD=10.41) manakala min berat ialah 67.75 (SD=15.69). Penentuan kepekatan iodin di dalam urin telah dijalankan dengan menggunakan kaedah *modified micromethod* daripada *Sandell-Kolthoff Reaction.* Median kepekatan iodin dalam urin bagi responden menunjukkan kekurangan yang serius, iaitu 8.5 µg/L. Ujian korelasi menunjukkan terdapat hubungan yang signifikan antara status sosio-ekonomi dan kepekatan iodin dalam urin ($r = -0.251$, $p < 0.05$). Di samping itu, tiada hubungan yang signifikan di antara pengambilan makanan dan kepekatan iodin di dalam urin. Sebagai kesimpulan, penentuan dan pengawalan terhadap status pemakanan iodin adalah penting walaupun untuk populasi yang tidak berisiko terhadap kekurangan iodin, terutamanya untuk wanita mengandung. Pengurusan yang berterusan terhadap iodin, bermula dari awal kehamilan dan berterusan sehingga tempoh menyusu adalah sangat digalakkan. Pendidikan mengenai kesihatan juga perlu diberikan untuk memastikan pengambilan iodin adalah mencukupi disebabkan wanita mengandung merupakan kumpulan yang berisiko terhadap kekurangan pengambilan iodin.

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LIST OF ABBREVIATIONS

AT	Ambient temperature
ECF	Extracellular fluid
FAO	Food and Agriculture Organization
FFQ	Food Frequency Questionnaire
hCG	Hormone chorionic gonadotropin
ICCIDD	International Council for the Control of Iodine Deficiency Disorders
ID	Iodine deficiency
IDDs	Iodine deficiency disorders
IOM	Institute of Medicine
SCN	Thiocyanate
IQ	Intelligent Quotient
MOH	Ministry of Health
MTP	Microtitre plate
MUIC	Median urinary iodine
NIS	Sodium iodide symporter
PII	Plasma inorganic iodine
RNIs	Recommended Nutrients Intakes
T3	Triiodothyroxine
T4	Thyroxine
TBG	Thyroxine-binding globulin
Tg	Thyroglobulin
TH	Thyroid hormone
TSH	Thyroid stimulating hormone

UI	Urinary iodine
UIC	Urinary iodine concentration
USI	Universal Salt Iodization
WHO	World Health Organization
μg	microgram

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Iodine is one of the most important trace elements in the human body. It is important during the synthesis of thyroid hormones, which play a determining role in the process of the early stage of growth and development of most organs, especially the brain, in human during foetal and early postnatal life (Delange, 2000). Iodine is primarily obtained through the diet, but it is also a component of some medications (Food and Agriculture Organization [FAO]/ World Health Organization [WHO], 2004). Main sources of dietary iodine are iodized salt, saltwater fish, seaweed and grains, although only trace amounts are present in the latter (Ristic-Medic et al., 2009). In human body, dietary iodine is converted into the iodide ion in the gut lumen, and >90% is rapidly absorbed in the upper small intestine (Ristic-Medic et al., 2009). Fifteen percent of ingested iodine is taken up by the thyroid gland within 24 hour of ingestion, and the excess is excreted by the kidney in urine (European Food Safety Authority, 2006).

Iodine deficiency in human can cause a wide range of health related problems that are collectively called Iodine Deficiency Disorders (IDDs). Low level of thyroid hormones in the body due to lack of adequate iodine in foods and drinks is responsible for IDDs (Hetzel, 1983; Hetzel et al., 1990). The adverse effects of low iodine intakes can occur at all stages of the life cycle but the greatest impact during periods of rapid growth and development. An estimated 200-300 million people worldwide show some degree of IDDs (World Health Organization [WHO]/ International Council for the Control of Iodine Deficiency Disorders [ICCIDD]/ United Nations Children's Fund [UNICEF], 2007), especially in Asia and Africa but also in large parts of Eastern Europe (WHO, 2007). WHO has identified several groups in the population who are particularly vulnerable to sub-optimal iodine intakes, such as pregnant women and children (WHO/ICCIDD/UNICEF, 1993). According to the WHO, IDDs are among the major public health problems of the world, particularly of pregnant women and young women in many developing countries (de Benoist et al., 2004). In 1994, the worldwide prevalence of IDDs indicated a problem in 118 countries, affecting 1572 million people. Of the world's population, 655 million, or 12% were affected by goitre, 11.2 million were affected by cretinism, and 43 million were affected by some degree of mental impairment (WHO/ICCIDD/UNICEF, 1993).

Several studies have shown that there are many factors contributing to the IDDs. Pregnancy, parity, food habits, socioeconomic, and smoking are known risk factors for iodine deficiency (Noran et al., 2005). During pregnancy, there is an increase in the thyroid hormone requirements due to the physiological modifications produced in response to the metabolic demands of pregnancy (Prieto et al., 2011). Pregnancy can induce iodine deficiency and goitre formation due to the increase in the body's requirement for iodine (Lazarus, 2002). A diet deficient in iodine can lead to a number of IDDs that include a wide range of mental and physical disorders (Morreale de Escobar et al., 2007). Endemic congenital hypothyroidism in the offspring of women with severe iodine deficiency during pregnancy is considered the world's most prevalent preventable cause of mental retardation (Stanbury & Hetzel, 1980; Dunn, 1993).

A survey on National IDDs in 1996 showed that IDDs was not a public health problem in Peninsular Malaysia (National Coordinating Committee on Food and Nutrition, 1996). But now, it becoming worst especially in the East Coast region (Rusidah et al., 2010). From a study that have been conducted in rural, among Malay women of reproductive age living on the outskirts of Kuala Lumpur, it has been found that the goiter prevalence is about 23 to 24.5% (Osman & Zaleha, 1995). According to Rusidah et al. (2010), the result of the studies that has been conducted in children, indicated that Malaysia is currently in borderline iodine sufficient with median Urinary Iodine Concentration (UIC) of 109.0 µg/L, and interquartile range of 67.1 to 166.3 µg/L. The deficiency more marked in 6 states: Kedah, Penang, Perak, Pahang, Terengganu, Kelantan.

1.2 Problem statement

IDDs is one of a global health problem, but it has not been taken seriously because only limited studies have been reported about this cases. According to Rusidah et al. (2010), iodine deficiency is not confined only to the remote or interior areas but also occur in coastal areas like Terengganu and also urban areas, such as in Penang. A study should be conducted in order to determine the factors that contribute to this problem.

In Malaysia, there was a study on the iodine status of primary school children aged 8-10 years old both urban dan rural schools. Based on the studies, Malaysia has been found to be in borderline iodine sufficient (Rusidah et al., 2010). That means the prevalence of iodine deficiency has been arise in the East Coast of Peninsular Malaysia. The iodine status could be low since born and also because of some factors like age, gender, dietary pattern and others. Besides, there is only limited data on iodine status of pregnant women in Malaysia and no study reported for iodine status in pregnant women in Kelantan.

1.3 Significant of the study

There are not much studies of iodine assessment among the Malaysian. In addition, there are many research have been conducted on iodine status of school children and adult but only limited studies investigated the iodine status in pregnant women in Malaysia, especially in the East Coast of Peninsular Malaysia. Until now, public only have limited information about the importance of iodine and the consequences of IDDs. So, this study later can show the awareness of public and reflect the real picture about the importance of iodine and the risk of iodine deficiencies in Malaysia. Besides, the WHO, has identified pregnant women and children are the groups that particularly vulnerable to sub-optimal iodine intakes. It is important to study the iodine status on pregnant women because the development of the fetus depends much on their mother nutrition status during the pregnancy stage. This iodine status during pregnancy also can affect their offspring later.

So, the data from this study can be used by the governmment to decrease the risk of effect on iodine deficiency in the offsprings. From this study, it might be useful to give the latest iodine status among Malaysian and what the right action can be taken based on the result of this study. In addition, it also can contribute to assist in finding the solution to decrease the IDDs. Besides, this studies also important to provide information to the government to improve the quality of food intake and programme to increase the awareness on the importance of iodine adequancy among Malaysian.

1.4 Objective

1.4.1 General objective

The purpose of this study is to collect information about iodine status and the prevalence of Iodine Deficiency Disorders (IDDs) among pregnant women in East Coast of Peninsular Malaysia as well as the risk factors associated with the problem.

1.4.2 Specific objectives

1. To investigate the iodine status of pregnant women in Kelantan.
2. To determine the relationship between socio-demographic factors and iodine status of pregnant women.
3. To determine the relationship between dietary intake and iodine status of pregnant women.

CHAPTER 2

LITERATURE REVIEW

2.1 Iodine in human body

Iodine (atomic weight 126.9 g/atom) is a fundamental component of the thyroid hormones produced by the thyroid gland, that are essential for mammalian life (Zimmermann et al., 2008; WHO/ICCIDD/UNICEF, 2007). In 1895, Baunmann has found iodine in the thyroid gland (Baunmann, 1896). Iodine is regarded as a trace element that is essential for human growth and development, because the thyroid gland depends on iodine for the production of the thyroid hormones, which are triiodothyronine (T3) and thyroxine (T4) (Charlton et al., 2010).

The thyroid gland uses iodine for synthesis of the hormones T3 and T4, which are essential for maintenance of the body's metabolic rate by controlling energy production, and oxygen consumption in cells, for normal growth, and for neural and sexual development (Larsen et al., 1981). According to Ristic-Medic et al. (2009), thyroglobulin is the most abundant thyroid protein and it is a key precursor in the production of thyroid hormone. The synthesis and release of thyroid hormones are regulated by thyroid- stimulating hormone (TSH or thyrotropin). It is released from the pituitary gland into the circulation. This regulation is subject to feedback inhibition.

2.1.1 Food sources

The native iodine content of most foods and beverages is low. In general, commonly consumed foods provide 3 to 80 μg per serving (Pennington et al., 1995; Haldimann, 2005). The iodine content of foods varies with geographic location, ranging widely from 30 μg/100 g to 800 μg/100g (FAO/WHO, 2002). The iodine content of foods also depends on the iodine content of the soil in which it is grown. Seafood has been found to be the best natural iodine sources (Koutras, 1986).

According to Zimmermann (2009), the foods of marine origin have higher iodine content because marine plants and animals concentrate iodine from seawater. Seafood such as clams, lobsters, oysters, sardines, and other saltwater fish is the richest source of iodine (Gallagher, 2008). Saltwater fish contain 300 to 3000 mcg/kg of flesh while freshwater fish contain 20 to 40 mcg/kg, but they are still good sources (Gallagher, 2008). Additionally, seaweed is a rich source of iodine. Thus, populations living near the sea and consuming seaweeds and rich fish such the Japanese have a high intake of iodine. The amount of iodine intake by the Japanese is in the range of 2-3 mg/day (Koutras, 1986).

The iodine content of cow's milk and eggs is determined by the iodides available in the diet of animal, while the iodide content of vegetables varies according to the iodine content of the soil in which they grow (Gallagher, 2008). According to Zimmermann (2009), iodine content in foods is also influenced by iodine-containing compounds used in irrigation, fertilizers, and livestock feed. Iodophors used in dairy processing also can increase the native iodine content of dairy products. Example of iodine content in foods are shown in Table 2.1. However, the iodine content in fish available in Malaysia has not been determined yet.

Table 2.1: Iodine contents in foods

Food	Fresh basis		Dry basis	
	Mean	Range	Mean	Range
Fish (Freshwater)	30	17-40	116	68-194
Fish (marine)	832	163-3,180	3,715	471-4,591
Shellfish	798	308-1,300	3,866	1,292-4,987
Meat	50	27-97	-	-
Milk	47	35-56	-	-
Eggs	93	-	-	-
Cereal grains	47	22-72	65	34-92
Fruits	18	10-29	154	62-277
Legumes	30	23-36	234	223-245
Vegetables	29	12-201	385	204-1636
Iodized salt*	25 mg/kg	20- 30 mg/kg	-	-

*Malaysian Food Regulation 1985 (Regulation 285)

Source: FAO/WHO (2002)

2.1.2 Absorption and metabolism of iodine in the body

Iodine is ingested in several chemical form, which is rapidly and almost completely absorbed in the stomach and duodenum (Zimmermann, 2009). Iodine that is obtained through the diet is mainly absorbed by the gastrointestinal tract as the inorganic anion, iodide (Soldin, 2002). According to Glinoer (2004), the iodide of dietary origin mixes rapidly with iodide resulting from the peripheral catabolism of thyroid hormones (and iodothyronines) by deiodination, and together they constitute the extrathyroidal pool of plasma inorganic iodide (PII). This pool is in a dynamic equilibrium with two major organs, which are the thyroid gland and the kidneys.

According to Alexander et al. (1967), the absorption of iodide in healthy adults is greater than 90%. Thyroid gland secretes 80 µg of iodine as T3 and T4 hormones per day, with 40 μg of iodine secreted appear in extracellular fluid (ECF) per day (Pal, 2007). The distribution space of absorbed iodine is almost equivalent to the extracellular fluid volume (DeGroot, 1966). T3 and T4 are metabolized in liver and releases about 60 μg of iodine into ECF and 20 μg of iodine into the bile to be excreted in stools later (Pal, 2007). The iodine is then cleared from the circulation mainly by the thyroid and kidney, whereas renal iodine clearance is quite constant and the thyroid clearance varies with iodine intake (DeGroot, 1966). On average, 480 μg of iodine get excreted in urine and 20 μg in stools per day (Pal, 2007).

In conditions of adequate iodine supply, ≤10% of absorbed iodine is taken up by the thyroid. In chronic iodine deficiency (ID), this fraction can exceed 80% (Zimmermann, 2009). According to Fisher & Oddie (1969), the body of a healthy adult contains about 15- 20 mg of iodine, of which 70%- 80% is concentrated in the thyroid gland. The content of the thyroid may drop to below 20 μg in the state with chronic iodine deficiency. In iodine-adequate areas, the adult thyroid traps about 60 μg of iodine per day in order to balance losses and sustain thyroid hormone synthesis (DeGroot, 1966; Stanbury et al., 1954; Wayne et al., 1964).

2.1.3 Metabolism of iodine during normal pregnancy

In pregnancy, there is a significant increase in renal iodide clearance (by ~1.3-~1.5-fold) and along with, a sustained increasement in thyroid hormone (TH) production requirements (by ~1.5-fold), from 80 to 120 μg of hormonal iodide/day. Since the renal iodide clearance already increases in the first weeks of gestation and persists thereafter, this constitutes an obligatory iodine 'leakage' which tends to decrease circulating plasma inorganic iodide (PII) levels and, in turn, induces a compensatory increase in the thyroidal clearance of iodide. According to Pochin (1952); Halnan (1958); Aboul-Khair et al. (1964); Silva (1985); Liberman et al. (1998), these mechanisms highlight an increased physiologic thyroidal activity during pregnancy.

Figure 2.1 shows that when the daily iodine intake is only 70 µg during pregnancy, and despite an increase in glandular uptake to 60%, the equilibrium becomes more or less rapidly unbalanced, since the iodide entry resulting from both uptake and recycling is not enough to fulfil the increased requirements for TH production. In that condition, ~20 µg of iodine are missing daily. The glandular machinery must draw from already low intrathyroidal iodine stores in order to sustain TH production (Glinoer, 1997a, 1997b; Glinoer, 2001). Therefore in about one trimester after conception, the already low intrathyroidal iodine stores become even more depleted. When iodine insufficiency prevails during the first half, it then tends to become more severe with the progression of gestation to its final stages (Glinoer & Delange, 2000).

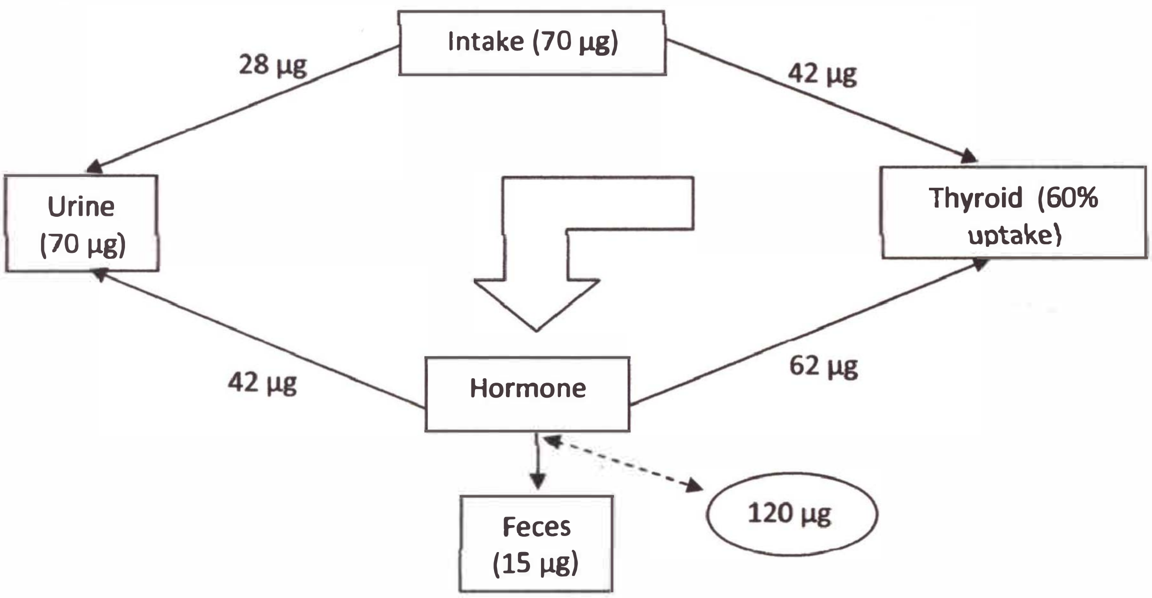

Figure 2.1: Schematic representation of the kinetics of iodide in healthy pregnant

According to Glinoer (1997), the condition is rationale for the excessive stimulation of the thyroid gland observed during a pregnancy that takes place in iodine-deficient conditions. This condition can cause relative hypothyroxinaemia, preferential secretion of tri-iodothyronine, an increased concentration of serum thyroid-stimulating hormone as well as serum thyroglobulin and also increase in thyroid volume leading to goitre (Glinoer, 1997).

2.1.4 Regulation of thyroid function during normal pregnancy

The main change in thyroid function associated with the pregnant state is the requirement of an increased production of thyroid hormone that depends directly on the adequate availability of dietary iodine and integrity of the glandular machinery (Glinoer, 2004). The thyroid undergoes metabolic and hemodynamic changes during pregnancy as levels of thyroxine-binding globulin (TBG), renal clearance of iodide, and transplacental passage of iodide and thyroid hormones all increase (Glinoer, 2001).

Pregnancy state is a condition that related with intense modifications in the regulation of thyroid function and economy. It is due to separate physiological events that take place at different points in time during gestation and this form a challenge for the maternal thyroid, because together these events exert stimulatory effects on glandular machinery (Glinoer, 1997). According to Pearce et al. (2007), iodine regulation varies across the three trimesters as metabolic needs change. Then, after parturition, maternal iodine continues to be the only source of iodine to the breast-fed neonate. Sodium iodide symporter (NIS) is present in breast tissue and is responsible for concentrating iodine in colostrums and breast milk (Pearce et al., 2007). Figure 2.2 shows the regulation of the thyroid function in pregnancy.

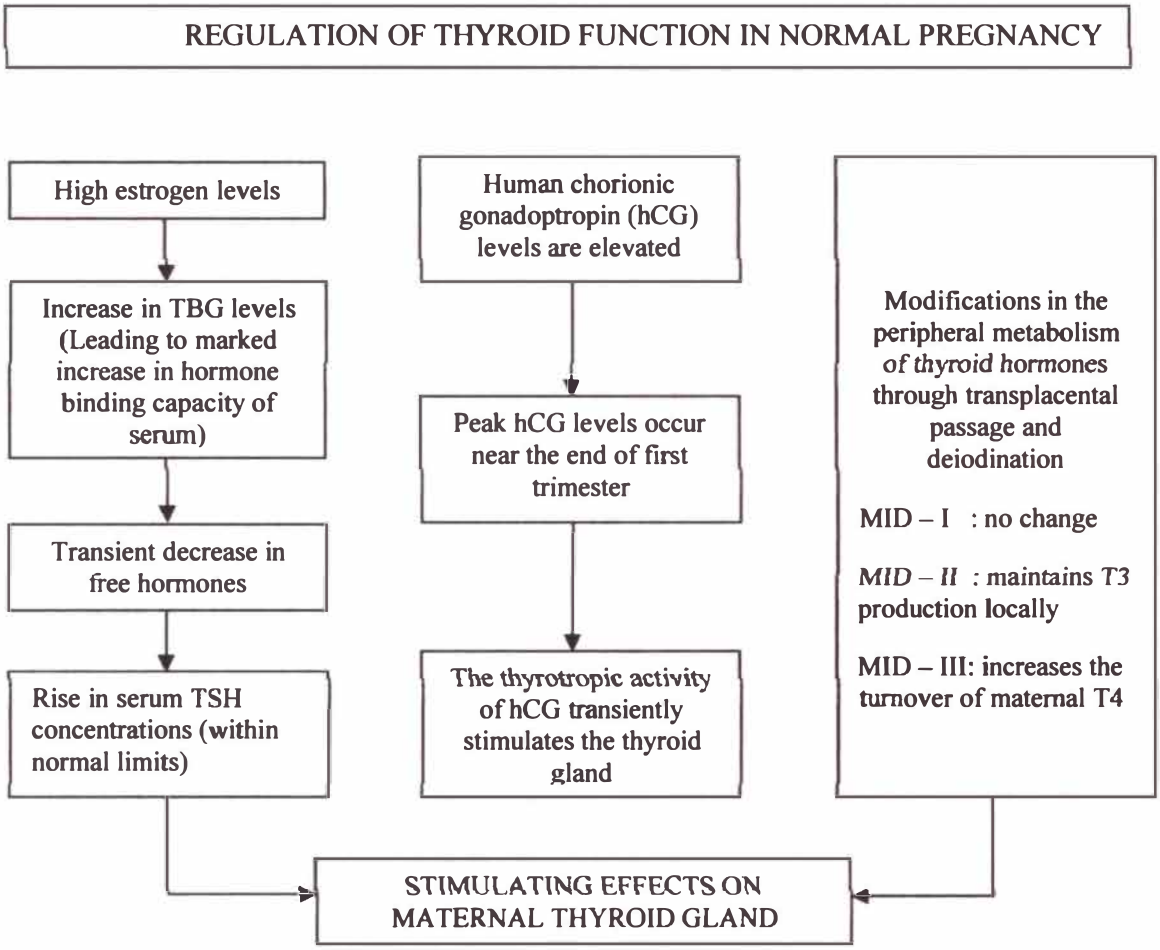

Figure 2.2: The regulation of the thyroid function in pregnancy.

During pregnancy, the elevated of estrogen concentrations will influence the increasing of the serum thyroxine-binding globulin (TBG) concentrations, which begins during early gestation and reaching a plateau at mid- gestation, maintained thereafter (Glinore et al., 1990). An increase in renal blood flow and glomerular filtration also begin in early gestation, which lead to the increasing of iodide clearance from plasma and, hence, to an obligatory loss of iodine (Dworkin et al., 1966).

By occurring transiently near the end of the first trimester, there is a direct stimulation of the thyroid gland by elevated concentrations of human chorionic gonadotropin (hCG), that may temporarily lead to slightly increased free T4 concentrations (Guillaume et al., 1985; Glinoer et al., 1993). hCG is produced by the syncytiotrophoblasts of the developing pregnancy and its production begins in the first days of pregnancy and peaks at 9-11 weeks of gestational age. The levels then decline until approximately 20 weeks of gestation and remain stable for the rest of the pregnancy (Hershman, 2004). Lastly, the significant modifications in the peripheral metabolism of maternal thyroid hormones occur in the second half of gestation, which mainly depends on the placental type 3 iodothyronine deiodinase (Galton et al., 1999; Bianco et al., 2002).

According to Glinoer (1999), all the events represent a profound metabolic change and associated with the progression of gestation during its first half, that constitutes a transition from the preconception thyroidal steady-state to the pregnancy steady-state. To accomplish, a metabolic changes need the increased of hormone production by the maternal thyroid gland and the increased hormonal demands are sustained until term once the new equilibrium reached.

For healthy women with sufficient iodine intake, the thyroid gland need to adjust its hormonal output in order to achieve a new equilibrium and maintain it thereafter until term: this corresponds to physiological adaptation of the thyroidal economy to the pregnant state (Glinoer, 2000). In contrast, the physiological adaptation is progressively replaced by pathological alterations in pregnant women whose reside in restricted iodine intake. Pregnancy typically acts therefore to reveal the underlying iodine restriction, which is the more severe the iodine deficiency, the more pronounced the maternal and foetal thyroidal consequences (Glinoer, 1994, 1995, 1996, 1997, 2001).

2.1.5 Measurement of iodine concentration in the body

2.1.5.1 Urinary iodine concentration

Urinary iodine (UI) is an remarkable indicator of recent iodine intake because at the end, more than 90% of dietary iodine appears in the urine (Nicola et al., 2009; Vought & London, 1967). According to Zimmermann (2009), UI can be expressed as a concentration (micrograms per liter), in relationship to creatinine excretion (micrograms iodine per gram creatinine), or as 24-h excretion (micrograms per day). For populations, because it is impractical to collect 24-h samples in field studies, so UI can be measured in spot urine specimens from a representative sample of the target group and expressed in micrograms per liter as the median, (WHO/UNICEF/ICCIDD, 2007). Moreover, the median UI is recommended by WHO/ICCIDD/UNICEF (2007) for assessing iodine nutrition in pregnant women.

The median UI does not provide direct information on thyroid function, but a low value of UI suggests that a population is at higher risk of developing thyroid disorders (Zimmermann, 2009). UI concentrations reflect recent changes in iodine intake (Rasmussen et al., 1999) and thus allow for monitoring intakes over time and comparison between countries (WHO/UNICEF/ICCIDD, 2007).

2.1.5.2 Thyroid size

According to Zimmermann (2009), neck inspection and palpilation and the thyroid ultrasonography are the methods available for measuring goiter. By palpilation, a thyroid is considered goitrous when each lateral lobe has a volume greater than the terminal phalanx of the thumbs of the subject being examined. In WHO (2007) classification system, grade 0 is defined as a thyroid that is not palpable and visible, grade 1 is a goiter that is palpable but not visible when the neck is in the normal position, and grade 2 goiter is a thyroid that is clearly visible when the neck is in a normal position.

Based on the studies, Zimmermann et al. (2000), it has been found that measurement of thyroid volume by ultrasound is preferable in areas of mild iodine deficiency. It is because the palpation of goiter in the areas has poor sensitivity and specificity. Thyroid ultrasound is noninvasive, quickly done (2-3 min per subject), and practical even in remote areas using portable equipment (Zimmermann, 2009). According to WHO/ICCIDD/UNICEF (2007), the total goiter rate used to define severity are: <5%, iodine sufficiency, 5-19.9% mild deficiency, 20-29.9% moderate deficiency, >30% severe deficiency.

In areas of endemic goiter, although thyroid size predictably decreases in response to increases in iodine intake, thyroid size may not return to normal for months or years after correction of iodine deficiency (Aghini-Lombardi et al., 1997; Zimmermann et al., 2003). It is due to the difficulty in interpreting the goiter rate during this transition period, because it reflects both a population's history of iodine and its present status (Zimmermann, 2008).

2.1.5.3 Thyroid stimulating hormone

The pituitary secretes TSH in response to circulating levels of T4. Serum TSH rises when serum T4 concentration are low, and falls when they are high. Iodine deficiency lowers circulating T4 and raises the serum TSH, so iodine-deficient populations commonly have higher serum TSH concentrations than the iodine sufficient group (WHO/ICCIDD/UNICEF, 2007). According to Zimmermann (2009), thyroid stimulating hormone (TSH) can be used as an indicator of iodine nutrition because serum TSH is determined mainly by the level of circulating thyroid hormone, which in turn reflects iodine intake.

TSH is relatively insensitive indicator of iodine nutrition in adult (WHO/ICCIDD/UNICEF, 2007). In school adult, although serum TSH maybe slightly increased by iodine deficiency, but the values often remain within the normal range (Delange, 2000; Delange et al., 1972; Dumont et al., 1963; Morreale de Escobar et al., 2004; Van Herle et al., 1976). In contrast, TSH is a sensitive indicator of iodine status in the newborn period (Delange, 1997; Zimmermann et al., 2005). It is because of the newborn thyroid contain less iodine but has higher rates of iodine turnover. Particularly when iodine supply is low, maintaining high iodine turnover requires increased TSH stimulation. Serum TSH concentrations are therefore increased in iodine-deficient infants for the first few weeks of life, a condition termed transient newborn hypothyroidism.

In area with ID, an increase in transient newborn hypothyroidism, indicated by >3% of newborn TSH values above the threshold of 5 mU/L whole blood collected 3-4 days after birth, suggests ID in the population (WHO/ICCIDD/UNICEF, 2007).

2.1.5.4 Thyroglobulin

Thyroglobulin (Tg) is synthesized only in the thyroid and is the most abundant intrathyroidal protein (Zimmermann, 2009). Tg falls rapidly with iodine repletion and it is a more sensitive indicator of iodine repletion than TSH or T4 (Benmiloud et al., 1994). A new assay for Tg has been developed for dried blood spots by a finger prick, which simplifying collection and transport and the dried blood spot Tg has been shown to be a sensitive measurement of iodine status and reflects improved thyroid function within several months after iodine repletion (Zimmermann et al., 2003; Zimmermann et al., 2006). Based on the studies conducted by Ristic-Medic et al. (2009), it has been found that Tg does appear to be a useful marker of iodine status in children and adolescents, but there was little evidence of its usefulness in other groups, and it does not appear to be useful during pregnancy and lactation.

2.2 Iodine requirements

Several methods like daily uptake and turnover of radioactive iodine can be used to estimate the requirement for iodine, provided the subjects tested have adequate iodine status any euthyroid (Fisher & Oddie, 1969). Since there is lack of scientific data on iodine requirements in Malaysia, the Technical Sub-Committee (TSC) has recommended to used the approach used by FAO/WHO (2002). According to National Coordinating Committee on Food and Nutrition (2005), the actual recommended nutrient intakes (RNIs) for Malaysia are based on the body weights of the local population.

The actual RNIs for Malaysia slightly lower than the values proposed by FAO/WHO (2002) due to the lower mean body weight of Malaysian. The iodine intake should meet the recommendation level in order to maintain a normal thyroid size and also to provide sufficient thyroid iodine stores for normal thyroid hormone synthesis (FAO/WHO, 2002). Table 2.2 summarizes the comparison of RNIs for Malaysians of various age groups.

Table 2.2: Comparison of recommended intake for iodine: RNI Malaysia (2005), RNI of FAO/WHO (2002), and RDA of IOM (2001)

Age groups	RNI (µg/day)	Age groups	RNI (µg/day)	Age groups	RDA (µg/day)
Infants 0 – 5 months 6 – 11months	 90 120	Infants 0 – 6 months 7 – 11 months	 90 135	Infants 0 – 6 months 7 – 12 months	 110 130
					RDA (µg/day)
Children 1 – 3 years 4 – 6 years 7 – 9 years	 72 108 104	Children 1 – 3 years 4 – 6 years 7 – 9 years	 75 110 100	Children 1 – 3 years 4 – 8 years	 90 90
Men 19 – 65 years > 65 years	 124 114	Men 19 – 65 years > 65 years	 130 130	Men 19 – 30 years 31 - 50 years 51 – 70 years >70 years	 150 150 150 150
Women 19 – 65 years > 65 years	 110 98	Women 19 – 65 years > 65 years	 110 110	Women 19 – 30 years 31 - 50 years 51 – 70 years >70 years	 150 150 150 150
Pregnancy 1st trimester 2nd trimester 3rd trimester	 200 200 200	Pregnancy 1st trimester 2nd trimester 3rd trimester	 200 200 200	Pregnancy 14 – 18 years 19 – 30 years 31 – 50 years	 220 220 220
Lactation 0 – 3 months 4 – 6 months 7 – 12 months	 200 200 200	Lactation 0 – 3 months 4 – 6 months 7 – 12 months	 200 200 200	Lactation 14 – 18 years 19 – 30 years 31 – 50 years	 290 290 290

Source: (National Coordinating Committee on Food and Nutrition, 2005)

According to Glinoer (2001), a women requirements for iodine in order to achieve physiological thyroid hormone production are increased during pregnancy and a sufficient amounts of thyroid hormone are needed for the proper development of the central nervous system of the foetus (Morreale de Escobar et al., 2004). Thus, the recommended iodine intakes during pregnancy are 250 µg/d compared with 150 µg/d for nonpregnant women (WHO/ICCIDD/UNICEF, 2007). The corresponding median urinary iodine concentration that indicates optimal iodine nutrition increase from 100-

199 μg/L (Zimmermann et al., 2007), in nonpregnant women to 150-250 μg/L during pregnancy (WHO/ICCIDD/UNICEF, 2007). Since the fetus and young infant are most vulnerable and since iodine requirements are greater than normal in pregnant and breastfeeding mother, there are special concerns about ensuring an adequate iodine intake during these periods (Laurberg et al., 2007). Based on Aboul-Khair et al. (1964), the iodine requirement during pregnancy is increased to provide the needs of the fetus and to compensate for the increased loss of iodine in the urine resulting from an increased renal clearance of iodine during pregnancy. It is due to an increase in maternal T4 production to maintain maternal euthyroidism and transfer thyroid hormone to the fetus in early gestation, before the fetal thyroid functioning and because of the iodine transfer to the fetus, particularly in later gestation (Glinoer, 1997).

These requirements have been derived from studies of thyroid function during pregnancy and in the neonate under conditions of moderate iodine deficiency. These data indicated that the iodine intake required to prevent the onset of subclinical hypothyroidism of mother and fetus during pregnancy, and thus to prevent the possible risk of brain damage of the fetus, is approximately 3.5 μg/kg/day or 200 μg/day (FAO/WHO, 2002). Based on the study conducted by Dworkin et al. (1966), it was found that five pregnant women were at balance when consuming approximately 160 μg/day, with no significant differences between pre- and postpartum. Several studies conducted by correlating the effects of iodine supplementation with changes in thyroid volume during pregnancy in order to estimate iodine requirements during pregnancy. Romano et al. (1991) and Pederson et al. (1993) have found that the total daily iodine intakes of approximately 200 μg/day during pregnancy prevented in increase in thyroid volume, whereas in a study of

Glinoer et al. (1995), total daily iodine intake of approximately 150 μg/day was insufficient to prevent an increase in thyroid size.

2.3 Major determinants of iodine intake

Iodine is a fundamental micronutrients for the organism which should be regularly administered through foods. The ingestion of iodine depends on the type of foods consumed, their origin and preparation (Prieto et al., 2011). All the factors and alimentary habits make it difficult for the daily iodine requirements of the population to be covered through diet (Prieto et al., 2011). In addition, iodine is not stored in the body and must therefore be continually replenished (Prieto et al., 2011). According to WHO/UNICEF/ICCIDD (2001), in normal conditions there is equilibrium between iodine intake and urinary elimination, and determination of iodine in urine (ioduria) constitutes a good indicator of iodine intake, with assessment of ioduria in a casual urine sample providing adequate information on the nutritional status of iodine (Candil, 2004). Figure 2.3 shows the major determinants of iodine intake in human.

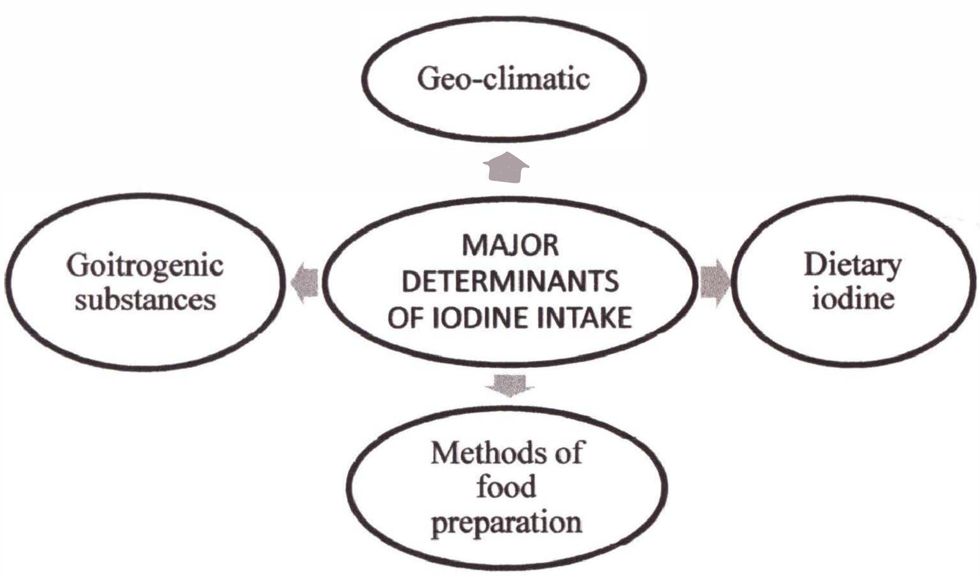

Figure 2.3: The major determinants of iodine intake

2.3.1 Geo-climatic

Iodine is widely but unevenly distributed in the earth's environment. In most of the regions in this world, the surface soils of iodide have been depleted due to the leaching from glaciations, flooding, and erosion (Zimmermann, 2009). The iodine-deficient soils are common in mountainous areas and the most severely deficient regions has been found in the Himalaya ranges, Andes, European Alps, and the mountains of China and areas of frequent flooding, especially in South and Southeast Asia (Zimmermann, 2009).

According to Hess (2010), most iodine is found in the oceans as iodide, and regions of glaciations, heavy rainfall and floods tend to have low iodine soil content, which leads to iodine deficiency in plants and animals grown on these soils. Consequently, population in such areas that depends on locally grown foods are at risk of developing iodine deficiency. Based on the studies conducted by Mazzarella et al. (2009), it showed that the iodine deficiency is more common in mountain areas than in lowlands, which is consistent with environmental conditions such as the lack of iodine in soil and water of mountainous areas (Ortner & Hotz, 2005).

2.3.2 Dietary iodine

The availability and consumption of iodine-rich food also affect the amount of iodine in the body. Accordingly, the native iodine content of most foods and beverages is low. In general, the foods that are commonly consumed can only provide 3 to 80 μg per serving (Pennington et al., 1995; Haldiman et al., 2005). According to Gowachirapant et al. (2009), the families who ate one or more seafood meals per week had higher UI values in both pregnant women and school-aged children than in families that ate none.

A study from Cuthbertson et al. (2000) has found that the study population had a high prevalence (32.4%) of goiter and a very low median urinary iodine level (14.5 $\pm$ 11.5 μg/L, n=34). Daily dietary intake has been found to be a possible factors contributing to the iodine deficiency. There are low consumption of iodine-rich food among *Orang Asli* community close to Kuala Lumpur, Malaysia (Cuthberson et al., 2000). In addition, they frequently consumed freshwater fish instead of marine fish because the freshwater fish can be freely obtained from fishing in the surrounding area, or occasionally from the local stores or fishmonger. It also has been found that there is less consumption of seafood because it is harder to access and more costly than other sources (Koutras, 1986). Besides, although the women consumed salt, iodized salt is limited and not commonly available in Peninsular Malaysia (National Coordinating Committee on Food and Nutrition, 1996).

Inhabitants of the coastal regions of Japan, whose diets contain large amounts of seaweed, have remarkably high iodine intakes amounting to 50 to 80 mg/d (Zimmermann, 2009). The study by Suzuki et al. (1965) found that the population in which excessive intake of iodine had been described as a main cause of disease for the population lived in some coastal areas of the Japanese island Hokkaido. Furthermore, the daily use of iodine-rich seaweed for consumption that also contributed to the excessive iodine in this population. This can cause toxicity if intakes many-fold higher the recommended level.

The risk of a certain thyroid disorders will depend on the level of iodine intake and on fluctuations in iodine intake (Laurberg et al., 2010). In addition, the risk of a number of thyroid diseases will depend on the interaction between iodine intake and genetics of the individual as well as exposure to other environmental factors (Knudsen et al., 2002). According to Laurberg et al. (2010), the level of iodine deficiency at which there may be risk of intellectual impairment is not fully established. Brain damage is not directly caused by lack of iodine, but it is indirectly due to the insufficient synthesis of thyroid hormones by the pregnant women, fetus and infants. The concequences of low iodine intake may become worse with the deficiency of other nutrients and intake of goitrogens that can interfere with enzymes or transporters used in the process of thyroid hormone synthesis (Laurberg et al., 2010).

2.3.3 Methods of food preparation

The methods of food preparations are also considered a factor that can affect the iodine intake in human. Iodine content in fish also depends on the cooking methods. Cooking methods like boiling, frying and grilling may deplete the dietary iodine intake further. Boiling has been estimated to decrease the iodine content in fish by half, and reduces approximately one-fifth of iodine content during frying or grilling (Koutras, 1986). A study that has been conducted by Harrison et al. (1965) with objective to determine the extent of iodine losses in fish during cooking has shown that the greatest losses were greatest after boiling, when an average of 58% of the iodine was lost, mainly by diffusion of iodine into the water, but some by fragmentation of small portions of fish. The corresponding losses after grilling and frying were 23% and 20%, respectively (Harrison, 1965).

Based on the study by Cuthbertson et al. (2000), the women of childbearing age in *Orang Asli* community near Kuala Lumpur had a severe public health IDDs problem and it also has been found that the commonly used cooking method are boiling and frying. In many countries, use of iodized salt in households for cooking and at the table provides additional iodine. There are no significant effect between food preparation and the decrease of iodine content in iodized salt. It has been found that boiling, baking, and canning of foods containing iodated salt cause only small losses, which is ≤10 % of iodine content (Chavasit et al., 2002).

2.3.4 Goitrogenic substances

2.3.4.1 Goitrogenic foods

Goitrogenic food is defined as some dietary substances that possibly interfere with iodine absorption in the body and also with thyroid hormone production and utilization (Osman et al., 1995; Osman et al., 1992; Delange et al., 1982; Gaitan, 1988). The example of goitrogenic foods are cruciferous vegetables, including cabbage, kale, cauliflower, broccoli, turnips, and rapeseed. These vegetables contain subtances name glucosinolates, by which their metabolites compete with iodine for thyroidal uptake. It is also similar with cassava, lima beans, linseed, sorghum, and sweet potato, which contain cyanogenic glucosides that may be metabolized to thiocyanates that also compete with iodine for the thyroidal intake (Ermans et al., 1972). It has been suggested that goitrogen-consuming communities have even greater iodine requirements, with the daily population requirement doubling-up from 150 to 300 μg (Hetzel, 1993). Individuals who consumed cassava more than two to four times per week had four times the risk of developing goitre (Osman et al., 1992).

For example, linamarin is a thioglycoside found in cassava, a staple food in many developing countries. According to Ermans et al. (1972), if cassava is not adequately soaked or cooked to remove the linamarin, it is hydrolyzed in the gut to release cyanide, which then metabolized to thiocyanate (SCN). Thiocyanate is believed to be a goitrogenic compound and it is a competitive inhibitor of the human thyroid/ iodide symporter NIS (Tonacchera et al., 2004; Dohan et al., 2003; Spitzweg et al., 2000).

According to Rao and Lakshmy (1995), the intake of goitrogenic substances causes an adaptive increase in T3's binding to brain nuclear receptors and also in the activity of type II 5'-deiodinase, which generates T4 to T3. This altered function and availability of T3 is harmful to the brain development (Rao & Lakshmy, 1995)

Soaking the cassava root for one day has been shown to reduce the thiocyanate content but one thing should be noted is that the thiocyanate levels vary in cassava and not all cassava is goitrogenic due to genetic and environmental factors (Delange et al., 1982). The study population in *Orang Asli* community close to Kuala Lumpur, Malaysia has found a high prevalence (32.4%) of goitre and a very low median urinary iodine level (14.5 µg/L). The cassava has been found to be their staple foods and was consumed daily by 43% of the participants and which might contribute to the IDDs (Cuthberson et al., 2000).

Soy foods are one of the foods that have been largely consumed in Asian countries. It is because of many potential benefits that have been linked to the intake of soy products according to epidemiological investigations (Anderson et al., 1995). However, there are also controversies about the effects of soy on human thyroid health and the health consequences related to the problem. According to Doerge & Sheehan (2002), genistein is the major isoflavone synthesized by the soybean and it possesses both estrogenic and goitrogenic activities in human body.

From previous studies on animals and human, soy foods are responsible on the antithyroid effect. Rodents are useful risk assessment models for thyroid toxicants, despite significant differences between rodent and human thyroid physiology (Poirier et al., 1999). Excessive soy intake has been reported to be responsible for the development of goiter, including thyroid enlargement, in both iodine-deficient rodents (McCarrison, 1933; Sharpless et al., 1939; Wilgus et al., 1941; Kimura et al., 1976) and infants fed soy-flour-based formula without iodine fortification (Pinchera et al., 1965; Shepard et al., 1960; Van Wyk et al., 1959). According to several studies, animals that have been fed with a soy diet require almost twice as much iodine compared with animals not fed soy (Sharpless et al., 1939; Block et al., 1961; Kay et al., 1988). The studies conducted by Chorazy et al. (1995) & Jabbar et al. (1997) shows that infants with congenital hypothyroidism who consume soy formula require ~25% more synthetic hormone than those on soy-free formulas.

In vitro research clearly shows that genistein is able to inhibit the activity of thyroid peroxidas, the enzyme involved in the synthesis of thyroid hormone (Divi et al., 1997). A study in rodents found that dietary genistein inhibited thyroid peroxidise activity by up to 60% (Chang & Doerge, 2000). Despite this enzyme inhibition, consumption of soy isoflavones does not appear to actually alter thyroid function since the thyroid hormones and the thyroid gland were unaffected in rats (Chang & Doerge, 2000; Doerge & Sheehan, 2002). The study concluded that soy could cause goiter, but only in animals or human consuming diets marginally adequate in iodine, or who were predisposed to develop goiter.

A human clinical trial conducted by Bitto et al. (2010) examined thyroid function in postmenopausal women taking a soy isoflavone supplement (54 milligrams of genistein) daily for 3 years. The results of this study showed that daily consumption of genistein had no effect on thyroid hormones, which remained within the normal range for the full duration of the study, did not alter the function of enzymes involved in thyroid hormone production, did not cause any changes in thyroid hormone auto-antibodies, and also had no effect on the expression of thyroid hormone receptors (Bitto et al., 2010). Individuals taking thyroid medications need to separate soy consumption and medication intake by 3 – 4 hours so as not to interfere with absorption of the medication (Jabbar et al., 1997; Bell & Ovalle, 2001; Pinchera, 1965).

2.3.4.2 Smoking

Smoking is considered as a goitrogenic substance since it inhibits the absorption of iodine during both gestation and the period of lactation (Laurberg et al., 2004). Smoking during gestational period is associated with changes in the levels of thyroid function in both the mother and the fetus. The TSH concentration in the mother (in the first and third trimester of gestation) and in the blood of umbilical cord are lower and the T3 levels are higher, which may trigger advance effects for both (Shields et al., 2009; McDonald et al., 2008). Laurberg et al. (2004) has found that smoking during lactation will increase the risk of iodine deficiency which may lead to brain damage in the lactating child.

Active smoking has been found to be associated with the development of hypothyroidism in both pregnant mother and the fetus (Ericcson & Lingarde, 1991). Gasparoni et al. (1998), reported that there was a significant difference in thyroglobulin and serum cyanate levels among infants with a father or parents who smoke between infants with non-smoking parents. It was also noted that the change in the thyroid function as evaluated by serum thyroglobulin observed at birth, can persist for at least a year if the exposure to smoking is sustained. According to MOH (1996), the prevalence of smoking male adult in Malaysia is 40%, with Kelantan having the highest prevalence. Based on the study conducted by Noran et al. (2005), on rural antenatal mothers in Bachok, Kelantan, it has been found that the prevalence of smoking among the husband was even higher at 69.5% and the antenatal mothers with a smoking husband has 2.1 times risk of developing iodine deficiency.

2.4 Prevalence of iodine deficiency

Worldwide, IDD remains a significant public health problem in 130 countries, although it has been eliminated in 61 countries (WHO/UNICEF/ICCIDD, 2001). It has been estimated that approximately 740 million people are affected by goitre while 2225 million people are at risk of IDD (MOH, 2005). WHO estimates that nearly 2 billion individuals have an insufficient iodine intake, including one third of all school-age children (de Benoist et al., 2003). According to Zimmermann (2009), only a few countries such as Switzerland, some of the Scandinavian countries, Australia, the United States, and Canada were completely iodine sufficient before 1990. Since then, globally, the number of households using iodized salt has risen from less than 20% to more than 70% and this is dramatically reducing iodine deficiency (Delange et al., 2002).

Australia and the United States are the two countries that previously iodine sufficient, but now iodine intakes are falling. Australia is currently mildly iodine deficient (Li et al., 2006) and in the United States, the median UI is 160 μg/L, still can be considered as adequate but it is half of the median value of 321 μg/L that found previously in the 1970s (Caldwell et al., 2008).

Several studies have been conducted on IDD in Malaysia, and it is primarily focused on population groups in Sarawak. The prevalence of endemic goiter in remote and rural areas in Malaysia was reported ranging from 20% to over 90% during the 1970s and 1980s (Chen & Lim, 1982; Kiyu et al., 1998). Based on the survey from MOH (1995), Malaysia has been implemented universal salt iodization (USI) in Sabah and the majority of districts of Sarawak. The eradication program in Sabah has been in effect since the implementation of USI. Despite this, the proportion of households consuming adequately iodized salt remains below the recommended target of >90% and this implies inadequate monitoring and law enforcement. In addition, this is also due to the lack of uniform access to iodized salt in the state (IDD Newsletter, 2010). Table 2.3 summarizes the studies conducted on IDDs in Peninsular Malaysia.

The IDDs studies in Orang Asli communities (target groups ranged from 7 years of age and over) in Peninsular Malaysia have indicated a high palpable goiter prevalence (26-45%), varying with location. The highest prevalence (Table 2.3) has been found in remote and rural village (Osman et al., 1992, 1995, 1996).

Table 2.3: Summary of the studies conducted on IDDs in Peninsular Malaysia

Population group (location, ethnicity, age group)	Objective	Palpable goiter prevalence / Mean UIC level	Conclusions	References
Kedah and Pahang (inland), Selangor (coastal): *OrangAsli*, 18 years and older	To assess prevalence of goiter among *Orang Asli* in selected areas	Inland, 30-44.7% Coastal, 6.0%	Inland prevalence higher	Osman et al.,1996

Kelantan: general population, 15 years and older	To determine prevalence of goiter in Kelantan	Inland,45.0% Coastal, 31.4%	Inland prevalence higher	Mafauzy et al., 1995
Kedah (inland): One Orang Asli village, two Malay villages; Selangor (coastal): Two Orang Asli village, one Malay village, age not reported	To determine and compare prevalence of goitre in remote inland areas and coastal areas	Inland,30.7% Orang Asli, 30.2% Malay,30.8% Coastal, 6.3% Orang Asli, 6.0% Malay, 6.7% **UIC**: inland, 17.9 g/L Coastal, 20.4 µg/L	No difference between ethnic groups. Inland prevalence higher	Osman et al., 1995
Six villages in Pahang: Two Orang Asli, four Malay, one Malay village in Kuala Lumpur; age: less than 11 years, adolescents, adults, elderly	To determine urinary iodine levels among Orang Asli and Malays in remote areas and to compare the two ethnic groups in Kuala Lumpur	**UIC**: Remote, 15 to 38 µg/L (all village in Pahang). Orang Asli, 24 µg/L, Malay,43 µg/L (exclude Kuala Lumpur village), Kuala Lumpur, 77 µg/L	Orang Asli had a significantly lower urinary iodine levels than Malays. Inland areas had significantly lower urinary iodine levels	Osman et al., 1994
One Malay and one Orang Asli village, 40 km from Kuala Lumpur, ≥7 years	To assess prevalence of goiter among Orang Asli, and compare to Malays	Orang Asli, 26.5% Malays, 19.6%	Slight difference between ethnic groups	Osman et al., 1992

Note: UIC= Urinary iodine concentration

Source: (Cuthberson et al. 2000)

2.5 Effects of iodine deficiency

Iodine deficiency has multiple adverse effects on growth and development in animals and humans. These are collectively termed as the iodine deficiency disorders (IDDs). IDDs resulted from inadequate thyroid hormone production due to lack of sufficient iodine (Zimmermann, 2009). The IDDs can cause the prevalence of hypothyroidism and also goiter. The hypothyroidism resulted when iodine intake falls below the recommended level and the thyroid no longer been able to synthesize sufficient amount of thyroid hormone- hypothyroidism. It responsible for damage to the developing brain and also give other harmful effects (Hetzel, 1983). Goiter is defined as the visible lump in the neck due to the enlargement of the thyroid gland. It occurs in ID condition, when the cells of the thyroid gland enlarge to trap as much iodide as possible (Whitney & Rolfes, 2008). Figure 2.4 and 2.5 show the example of effect of iodine deficiency.

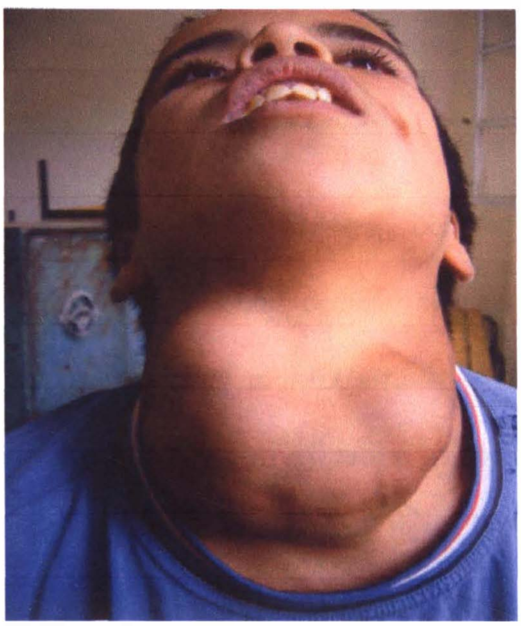

Figure 2.4: Large nodular goiter
Source: (Endocrine Review, 2009)

Figure 2.5: Neurological cretinism
Source: (Endocrine Review, 2009)

2.5.1 Pregnancy and infancy

A normal level of thyroid hormones is required for neuronal migration and myelination of the fetal brain, and lack of iodine irreversibly impairs brain development (Morreale de Escobar et al., 2004). Iodine deficiency also has a strong relationship on fetal brain development. Besides, the severe iodine deficiency during pregnancy can lead to the high risk of stillbirths, spontaneous abortions and congenital abnormalities. Of these, the most severe is spasticity (Melse-Boonstra & Jaiswal, 2010). Several studies have shown that iodine deficiency and hypothyroidism during pregnancy have long been known to be associated with neurological deficits and mental retardation (Pharoah et al., 1971; Haddow et al., 1999; Delange, 2001). Additionally, there is also evidence for an increased risk of adverse effects on obstetrical outcomes such as preeclampsia or placental abruption, and negative effects of the offspring such as preterm birth, fetal death, or low birth weight (Leung et al., 1993; Casey et al., 2005; Abalovivh et al., 2002; Das et al., 2006; Allan et al., 2000). Based on the study that has been conducted by Alvarez et al. (2009), it has been found that there is an association between thyroid function, iodine status, and prenatal growth.

In areas of severe chronic iodine deficiency, maternal and fetal hypothyroxinemia can occur from early gestation onward (Morreale de Escobar, 2004). According to McCarrison (1908), thyroid hormone is required for normal neuronal migration, myelination of the brain during fetal and early postnatal life and the hypothyroxinemia during these critical periods can causes the irreversible brain damage, with mental retardation and neurological abnormalities. The consequences are dependent on the timing and the severity of the hypothyroxinemia.

In addition, the thyroid hormone deficiency during the first and second trimesters of pregnancy would affect visual attention, visual processing, visuospatial skills and fine motor skills, whereas such deficiency during the second and third trimesters affects gross motor skills, memory and motor function. Post natal thyroid hormone deficiency would affect mainly language and verbal development, as well as attention and memory skills (Zoeller & Rovet, 2004).

2.5.2 Childhood

Several studies had indicated that the iodine deficiency is one of the major causes for children not to reach their full potential. It is also on a list of modifiable biological and psychosocial risks encountered by young children, and ranked in the third place (Jolly, 2007; Walker et al., 2007). Young children who received inadequate iodine are at risk of sub-optimal mental development and ability to learn (Bleichrodt et al., 1987).

According to Qian et al. (2005), children born to iodine-deficient mothers although may appear to be normal, have lower intelligent quotient (IQ) points, and it affects their ability to develop to their full potential and have learning difficulty in school. In the United States, the IQ scores of 7 to 9 year old children of mothers with subclinical hypothyroidism during pregnancy were 7 points lower compared with children from mother with normal thyroid function during pregnancy (Haddow et al., 1999). The studies that have been conducted on schoolchildren by Santiago-Fernandez et al. (2004), has suggests that IQ level in schoolchildren in developed country can be affected by iodine intake and the increase in dietary iodine to raise median urinary iodine output above 150 μg/L would enable the IQ to be increased several points in many of the children. In addition, a study that has been conducted by Hetzel (1995) on school children living in the iodine deficient areas from several countries showed impaired school performance and IQ compared to similar group from non iodine deficient areas. In addition, iodine supplementation has been found to improve cognitive and motor performance in iodine deficient school children (Zimmermann, 2006).

According to Mason et al. (2002), in five Asian countries, there is a correlation between household access to iodized salt and increased weight-for-age and mid-upper-arm circumference in infancy. However, controlled intervention studies of iodized oil alone (Bautista et al., 1982; Shrestha, 1994) and iodine given with other micronutrients (van Stuijvenbery et al., 1999; Rivera et al., 2001; Moreno-Reyes et al., 2003) generally have not found to affect the child growth.

2.5.3 Adulthood

In adults, mild-to-moderate iodine deficiency appears to be associated with higher rates of more aggressive subtypes of thyroid cancer, increase risk for diffuse goiter, and increases risk of nontoxic and toxic nodular goiter and associated with hyperthyroidism (Zimmermann et al., 2008; Laurberg et al., 2001). Based on the observational studies by Hetzel (1983), it also suggested widespread adverse effects in adults secondary to hypothyroidism, including impaired mental function with decreased educability, apathy, and also reduced work productivity.

Several studies showed that in mildly iodine-deficient areas, there is an increase in thyroid multinodularity in females with advancing age that is associated with a decrease in serum TSH (Knudsen et al., 2000a, 2000b). Together, these data argue that higher rates of hyperthyroidism in populations with mild iodine deficiency are likely due to a higher rate of multinodular toxic goiter. Thus, like diffuse goiter, thyroid hyperfunction also included in the spectrum of disorders caused by mild-to-moderate iodine deficiency (Zimmermann, 2009). Table 2.4 summarizes the effect of IDDs by age group.

Table 2.4: Effect of IDDs by age group

Life stages in life	***Effects***
All ages	Goiter Increased susceptability of thyroid gland to nuclear radiation
Fetus	Abortions Stillbirths Congenital anomalies Perinatal mortality Neurological cretinism
Neonate	Neonatal hypothyroidism Endemic mental retardation
Child and adolescent	Hypothyroidism &Hyperthyroidism Impaired mental function Retarded physical development
Adult	Hypothyroidism Impaired mental function Reduced work productivity Iodine-induced hyperthyroidism

Source: Hetzel (1983); Zimmermann et al. (2008)

CHAPTER 3

MATERIALS AND METHODS

3.1 Survey design and sampling

The present cross-sectional study was conducted from Jun to September 2011 and has been carried out in Kota Bharu that located at Kelantan in the East Coast of Peninsular Malaysia. The aim of this study was to collect information about iodine status of pregnant women in Kelantan. This survey utilized convenience sampling. The definition of convenience sampling is choosing respondents in which selection are based on the convenient to the researcher (Kumar, 1999). The eligible respondents of this survey were Malaysian pregnant womenbetween 16 and 42 years. The total respondents of this survey were 100 respondents. The formula below was used to calculate the sample size for 95% confidence level and the precision=0.5 was assumed (Yamane, 1967).

$$n = \frac{N}{1+Ne^2} = \frac{2\ 720\ 500}{1 + 2\ 720\ 500\ (0.05)^2} = 400$$

Population people in Kelantan = 1670 500 (Malaysia Department of Statistic, 2010). Estimation of pregnant women is 25% from 400 =100.

This survey was carried out in antenatal clinics, which are Klinik Kesihatan Desa Chempaka and Klinik Kesihatan Bandar Kota Bharu. In order to collect the data, a research ethical approval was obtained from Ministry of Health of Kelantan.

The places were selected because usually pregnant women will attend their antenatal checking at the antenatal clinics. In addition, the antenatal clinics also have specific days for the pregnant mother, make it easier to get the respondents. This survey was carried out in 3 months starting from May until September, 2011. Figure 3.1 shows the sample frame of this survey.

Figure 3.1: Sample frame of the survey

3.2 Subjects

A total of 100 pregnant women aged 16-42 years old were selected in this study. The pregnant women were chosen because they were one of the vulnerable groups to iodine deficiency and the most detrimental effects of inadequate nutritional iodine intake appear in pregnant women and children (Delange, 1994; Delange et al., 1993; Fenzi et al., 1990). Firstly, the screening process was done for the subject selection. Question regarding obstetric included during the screening process. The women who are post-natal mother were excluded from this study since the study only focused on pregnant mother.

3.3 Measurements

3.3.1 Questionnaire

A five parts of self-administrated questionnaire was used to obtain socio-demographic information, obstetric data, knowledge on iodine and IDDs, knowledge, practise and attitude towards iodized salt and also dietary data. Part 1 of the questionnaire consists of questions pertaining to socio-demographic variables. Data such as age, ethnicity, religion, educational level,employment status, household income, household composition, goiter history in family and smoking status were assessed.

For part 2, information on obstetric like gestational age, number of children, gravida, parity and number of miscarriages were also assessed. The basic knowledge on iodine and IDDs were assessed in part 3. For instance, the definition, function and dietary source of iodine source were included in the questionnaire. Besides, part 3 also include the question about the knowledge of IDDs and the management of IDDs. For part 4, the data of iodized salt user and iodine supplementation were assesed. In addition, the practise towards iodized salt were also included in part 4.

For part 5, information on dietary intake was collected using food frequency questionnaire (FFQ) and for this part, score of food frequency questionnaire from Chee et al. (1996) was used. Table 3.1 shows the scales used and example of the questionnaire.

Table 3.1: Scale used and example of questionnaire

Section	*Scales*	*Example*
Part 1 • Sociodemographic variables	Nominal	Ethnicity Household income Occupation Education level
Part 2 • Obstetric data	Nominal	Gestational age Parity Gravida Number of miscarriages
Part 3 • Knowledge in iodine *and IDDs*	Nominal Likert	Function of iodine in the body Good dietary sources of iodine *Factors affecting iodine absorption in* the body Effects of IDDs
Part 4 • Knowledge, practise and attitudes towards iodized salt	Nominal Likert	Consumption of iodized salt The timing of addition of iodized salt while cooking The storage of iodized salt Perception on the usage of iodized salt
Part 5 • Dietary intake *-Food frequency* questionnaire (FFQ) • Intake of iodine supplementations • Methods of food preparation	Nominal	Frequency of eating iodine-rich foods -seafood, shellfish *Frequency of eating goitrogenic food* -cassava, cabbage Usual method to cook fish and vegetables

3.3.2 Biochemical assessment

The urine collection has been used for iodine status determination. Urinary iodine concentration is the best method to determine the iodine status in population. It is because of urine sample is easy to obtain and more than 90% iodine from dietary intake are present in the urine (Dunn et al., 1993). The urine samples are collected by using mid-stream method in an unused disposable plastic cup with a tight-fitting lid. The urine samples were kept at -20°C until analysis. The Urinary Iodine Test that has been used in the study is the modified micromethod of Sandell-Kolthoff Reaction (Husniza & Wan Nazaimoon, 2006).

According to Husniza & Wan Nazaimoon (2006), this modified micromethod applied lesser amount of chemicals, thereby, saving cost of running IDD laboratories. The absorbance reading in 96-well plate microtitre plate (MTP) allowed more samples to be analysed at a time, thus, shortening the turnaround time. Besides, compared to chloric acid method, the amount of chemical waste produced is less, and is definitely a safer method to use since ammonium persulfate is less hazardous.

Firstly, 250 μl of urine samples and standards were added into glass test tube, followed by the addition of 1 ml ammonium persulfate, mixing and heating at 100°C for 1 hour. After cooled to AT, 30 μl of the samples and controls were transferred into corresponding wells of 96-well flat-bottomed polystyrene MTP. This was followed by addition of 60 μl of arsenious acid solution and 30 μl 0.019 M ceric ammonium sulfate into each well using repeating multichannel micropipette. The MTP was tapped gently to mix the reaction mixtures and followed by incubation at AT on a microplate shaker at 600 rpm shaking speed for 30 minutes. Absorbance was read at 405 nm using a microplate reader. The iodine concentrations of the unknown urine samples were determined from the standard curve of absorbance versus iodine concentration (μg/L). Figure 3.2 shows the summary of urinary iodine concentration determination using modified micromethod.

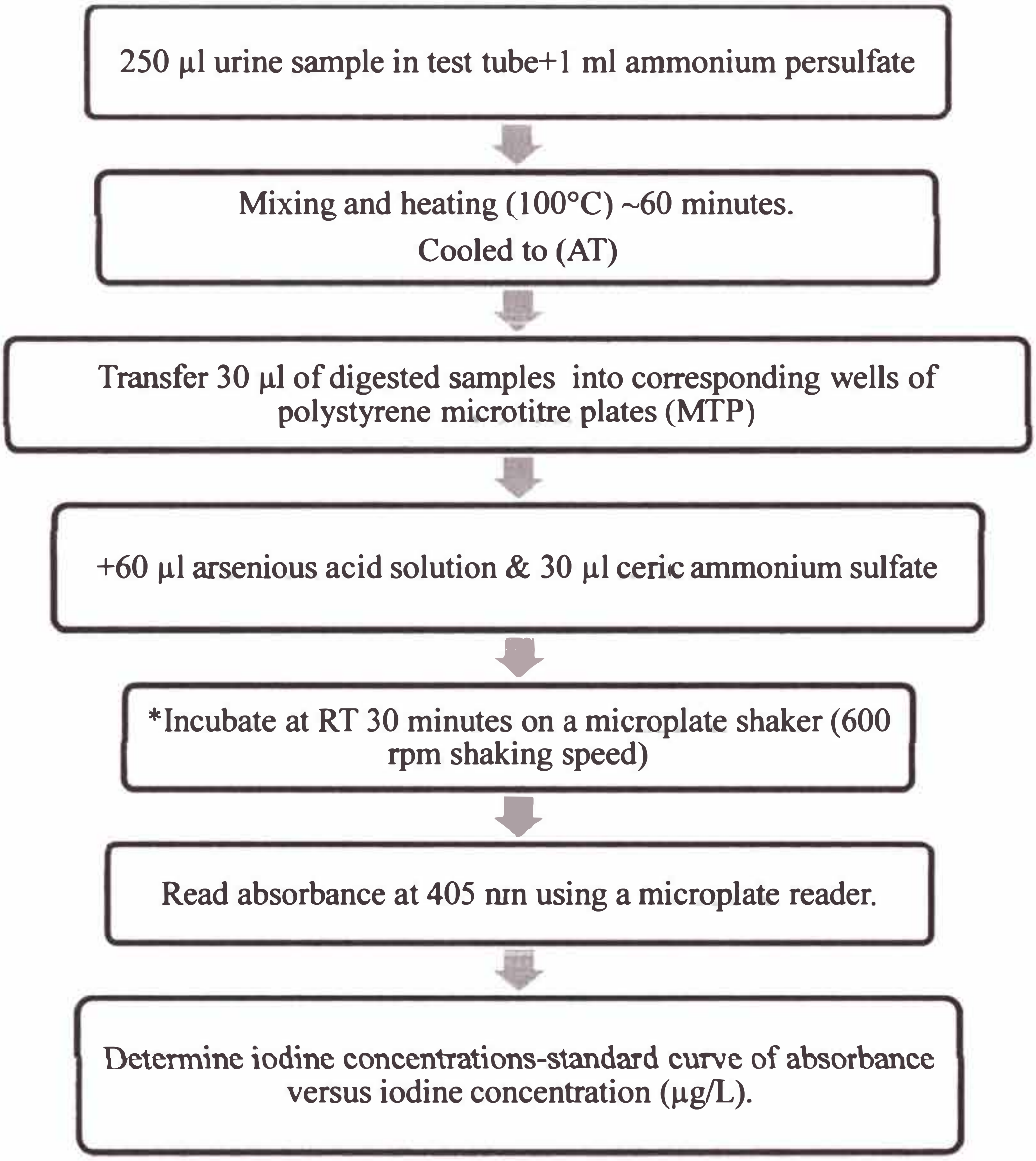

Figure 3.2: Determination of urinary iodine concentration (modified micromethod)

*Note: In Husniza & Wan Nazaimoon (2006), a journal with title "A cost-effective modified micromethod for measuring urine iodine", it was not stated that after addition of ceric ammonium sulphate, the solution need to be incubated for 30 minutes. Thus, unincubated samples might be the main reason why the UIC obtained was very low.

3.3.2.1 Chemical reagents

The chemical reagents used in this study are ammonium persulfate and potassium iodate obtained from R&M Chemical. Arsenic trioxide, sodium chloride and sodium hydroxide were obtained from SIGMA-ALDRICH (St.Louise, MO, USA). Ceric ammonium sulphate were obtained from MERCK (Darmstadt, Germany).

3.3.2.2 Equipment

For absorbance reading, it was measured with spectrophotometer at 405 nm wavelength. For dispensing reagents into the 96-well plate microtitre plate (MTP), Eppendoff model repeating multichannel micropipette was used.

Table 3.2: Criteria for assessment of iodine status by median UI in pregnant women

UI (μg/liter)	*Iodine status*
< 150	Insufficient
150 – 249	Adequate
250 – 499	More than adequate
> 500	Excessive

Source: (Zimmermann et al., 2008; WHO/ICCIDD/UNICEF, 2007)

3.4 Statistical analysis

All statistical analysis were performed using the Statistical Packaged for Social Science (SPSS) version 16.0. All data were checked for normality before analysis by using Kolmogorov-Smirnov test and Shapiro-Wilk test. If the data was normally distributed, mean and standard deviation will be used. But if the data was non-normally distributed, median, 10th and 90th percentiles will be used instead.

Besides, if normally distributed data, Pearson's correlation coefficient will be used instead to know the relationship between variables. In this study, Pearson's correlation were used to test the relationship between sociodemographic variables and UIC. Moreover, this correlation also used to know the relationship between dietary intake and IUC.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results and discussion

The pregnant women who attended the antenatal clinics are included in this study. A Total number of respondents who took part in this survey were 100 Malaysian pregnant women with age between 16 to 42 years. The mean age for this population is 29.39 (SD=5.729). The mean height of the population is 153.72 (SD=10.41) while the mean weight is 67.75 (15.69).

4.1.1 Socio-demographic characteristics of pregnant women

Socio-demographic data of pregnant women that involved in this study is shown in Table 4.1, which includes general classification aspects of age, ethnic group, religion, educational level, employment status, household income, household composition, goiter disease history and smoking status.

Socio-demographic data such as age, socioeconomic, educational level, goiter history and smoking status of husband was important to determine the iodine status of pregnant women. For example, Ericsson & Lingarde (1991) reported that active smoking has found to be associated with the development of hypothyroidism in both pregnant mother and the foetus.

Table 4.1: Socio-demographic characteristics of pregnant women

Characteristics	*Pregnant women (n=100)*	
	N	%
Age group (years)		
15-20	5	5.0
21-30	51	51.0
31-40	41	41.0
>40	3	3.0
Ethnic group		
Malay	94	94.0
Chinese	5	5.0
Indian	1	1.0
Religion		
Islam	94	94.0
Buddhist	5	5.0
Christian	1	1.0
Educational level		
No attend school	2	2.0
Primary school	2	2.0
Secondary school	59	59.0
Diploma/STPM	27	27.0
Degree	10	10.0
Occupation		
Manager	2	2.0
Professional	13	13.0
Technicians & associate professional	2	2.0
Service worker	7	7.0
Production Operator	1	1.0
Self-employed	13	13.0
Not working/housewife	46	46.0
Others	16	16.0
Household income		
<RM1500	41	41.0
RM1500-RM3000	30	30.0
RM3001-RM4000	12	12.0
RM4001-RM5000	8	8.0
RM5001-RM6000	5	5.0
>RM6000	4	4.0
Household composition		
2-3	28	28.0
4-5	42	42.0
6-7	15	15.0
>8	15	15.0
Goiter history		
Yes	3	3.0
No	92	92.0
Not sure	5	5.0

Smoking husband		
Yes	55	55.0
No	45	45.0

Among the respondents, the highest age group included was 21 to 30 years (51.0%) while the lowest was among those with 40 years and above (3.0%). Respondents with 15 to 20 years and 31 to 40 years are 5.0% and 41.0%, respectively.

The mean age for the population is 29.39 (SD= 5.729). When classified by the ethnic group, majority the respondents are Malay with 94.0%, 5.0% of Chinese and only 1.0% of Indian. Besides, highest religion among respondents was Islam (94.0%) followed by Buddhist (5.0%) and Christian (1.0%).

The highest educational level among respondents was secondary school at 59.0% while the lowest was among those with primary school and not attended school, both are at 2.0%. About 10.0% of the respondents had degree while 27.0% had educational level until diploma/STPM. From the study that has been conducted by Noran et al. (2005), majority the antenatal mother who included in the study also had attended secondary school with 80.7%. On the other hand, the study on Orang Asli with childbearing age found that half of the women had not attended school, while 45% had only attended primary school.

Moreover, when classified by employment status, most of the respondents were unemployed/housewives at 46.0%, 41.0% were an employee while 13.0% were self-employed. The study from Noran et al., (1995) also found that there are a large proportion of the mothers were unemployed/housewives.

In addition, the highest range of household income among respondents was less than RM1500 (41.0%) and the lowest range was more than RM6000 (4.0%).

From Table 4.1, most of the respondents (42.0%) were from the family with 4 to 5 members, followed by 28.0% with 2 to 3 family members and about 15.0% had household composition with more than 6 members.

From the data, it was found that only 3.0% of the respondents have goiter history in family, 92.0% have no goiter history while 5% were not sure whether they have goiter history in family or not. Besides, more than half (55.0%) of the respondent's husband were an active smokers while 45.0% were non-smokers. In previous study that has been conducted on rural antenatal mother in Bachok, Kelantan, it was found that a family goiter was present in 17 (5.0%) mothers, which slightly higher than this study. But from that 17 mothers with family goiter family, only 3 (17.6%) of them had iodine deficiency (Noran et al., 2005).

4.1.2 Obstetric data of pregnant women

The obstetric data of pregnant women include gestational age, number of children, gravid, parity and also the number of miscarriages. These data are some of the factors related to iodine deficiency. It also has been known that as severity of iodine deficiency increase the occurrence of poor pregnancy outcome such as miscarriage, stillbirth, and increased infant mortality is more likely (Hetzel, 1986; Pharoa et al., 1971; Thilly et al., 1980; McMichael et al., 1980). Iodine administration prior to conception or up to the second trimester can protect the fetal brain, and when give early enough reduces miscarriages as well as later pregnancy losses (Girling, 2008). According to Brix & Hegedus (2000), it has been found that parity is known to be associated with iodine deficiency. The obstetric data of pregnant women are shown in Table 4.2 .

Table 4.2: Obstetric data of pregnant women

Characteristics	*Pregnant women (n=100)*	
	N	%
Gestational age		
1st trimester	5	5.0
2nd trimester	28	28.0
3rd trimester	67	67.0
Number of children		
None	29	29.0
1	22	22.0
2-3	32	32.0
4-5	11	11.0
6-7	6	6.0
Gravida		
1	26	26.0
2-3	42	42.0
4-5	24	24.0
6-7	5	5.0
>8	3	3.0
Parity		
None	28	28.0
1	20	20.0
2-3	32	32.0
4-5	13	13.0
6-7	6	6.0
>8	1	1.0
Number of miscarriages		
None	86	86.0
1	12	12.0
2-3	2	2.0

Among respondents, the highest gestational age group was third trimester (67.0%), followed by second trimester (28.0%), and first trimester (5.9%). From Table 4.2, the highest range of number of children was 2-3 (32.0%), and the lowest with 6-7 children (6%). Besides, for gravida, it was found that 42.0% of the respondents only already have 2-3 pregnancies while only 3.0% already have more than 8 pregnancies. Moreover, for parity, 32.0% of respondents already giving birth for 2-3 times and only 1.0% have giving birth for more than 8 times. From the data, 86.0% of the respondents reported no miscarriages, 12.0% had only one miscarriage while the rest have experienced 2-3 miscarriages (2.0%).

4.1.3 Awareness and knowledge towards iodine and IDD

From Figure 4.1, it showed that most of the pregnant women in this study have heard about iodine, at 62.0%. Besides, 21% of them do not know about iodine while the rest (17.0%) were not sure if they ever know about iodine. These data indicate that more than 60% of Malaysian pregnant women aware about iodine. They possibly heard about iodine from the doctor in the antenatal clinics. In contrast, a study in South Eastern Nigeria has found only 13.3% know about iodine and iodized salt (Umenwanne & Akinyele, 2000). The different in the data may indicate that the knowledge and awareness could be different according to the geographical.

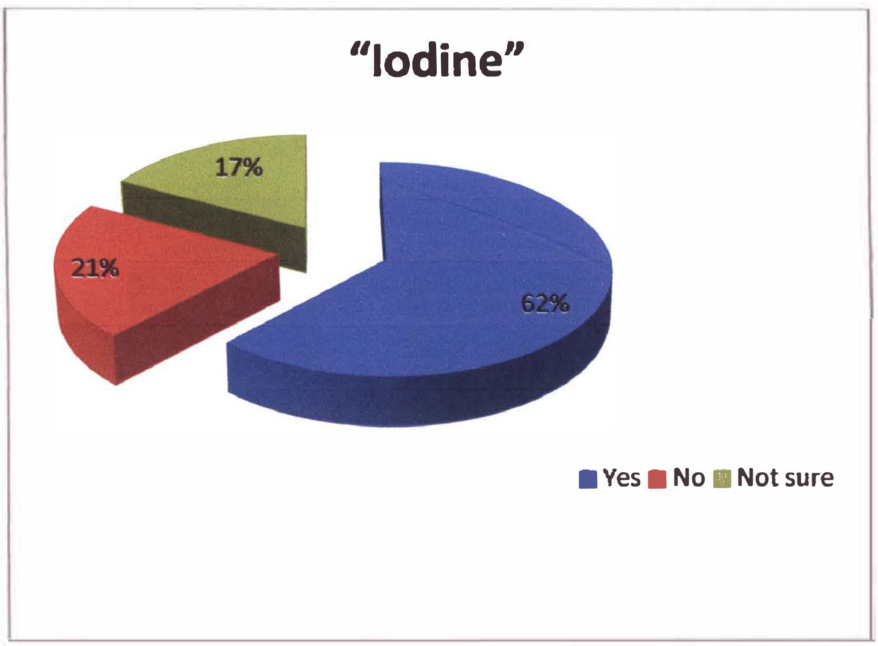

Figure 4.1: Awareness toward iodine

Figure 4.2 shows the percentage of respondent's knowledge on IDD. From this study, it was found that 53.0% of the pregnant women have basic knowledge on IDD. About 32.0% do not know about IDD while 15% of them do not sure whether they ever know about IDD or not. They probably got to know about IDD from many source like mass media or from health specialist. A study in Ethiopia found that over less than 10% heard about IDD (Abuye &Berhane, 2007). Besides, in Free State, South Africa, only 10.9% know about IDD (Sebotsa et al, 2009). Compared with the other studies, the present study showed that Malaysian pregnant women have more knowledge than the respondents in other countries. It maybe because iodized salt is widely distributed to pregnant women attending antenatal clinics all over Malaysia. In addition, they perhaps get more information about the IDD from the health professional during their visit in antenatal clinics.

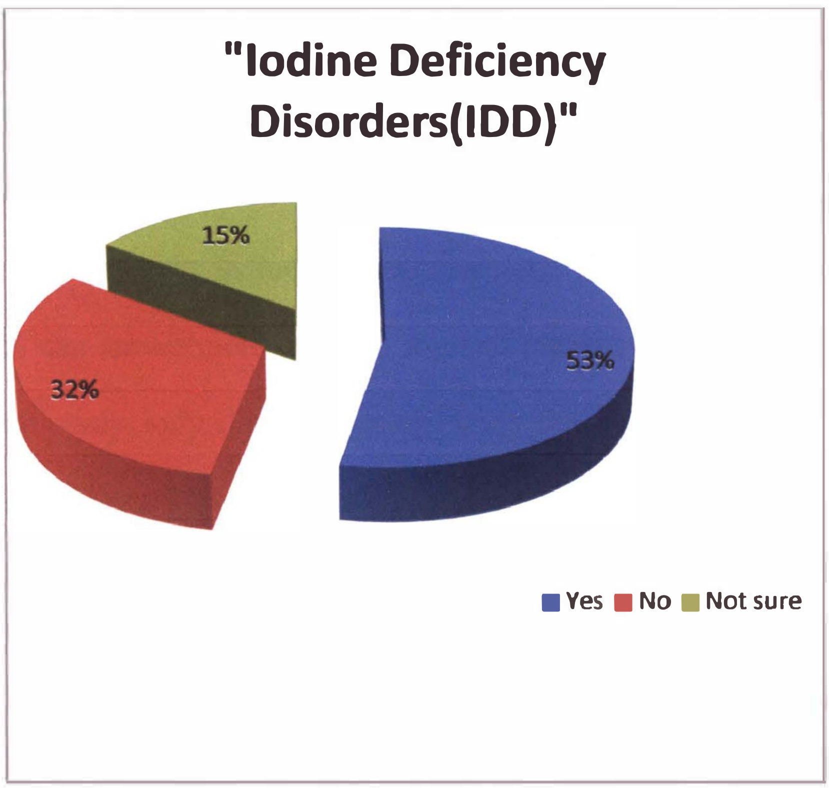

Figure 4.2: Respondent's knowledge on IDD

Table 4.3: Respondent interpretation of the statement on iodine

Statement	*n(%)*
Iodine is found in drinking water.	36
A higher iodine content is found in saltwater than freshwater fish	55
The highest iodine content are found in freshwater fish	34
Large amount of coffee and tea do not affect iodine absorption.	41
Consumed Cruciferae family do not have an effect on iodine balance of in the body.	21
Vegetables of Cruciferae family accelerate iodine absorption	9
The different methods of food preparation does not affect iodine losses.	41
Consumption of soy and peanuts lowers iodine absorption in the organism.	24the organism.

From Table 4.3, it showed that most pregnant women do not know that some foods can affect the absorption and iodine balance in body. They maybe knows about the basic information about iodine, but sometimes it is limited. From the data, 55% of the respondents agree that the iodine content in saltwater fish is higher than freshwater fish. Only 24% can answer correctly that soy and peanuts lower iodine absorption. Compare to other study, only slight percentage knew the soy and peanut consumption may affect iodine balance (Waszkowiak & Rogalewska, 2007). Less than half of the respondents knew that drinking a lot of coffee and tea limit iodine supply from everyday diet. Even worse results were recorded in case of questions concerning the effect of consumption of vegetables from *Cruciferae* family on the absorption of iodine supplied in the diet. In individual participating in the study, a low level of knowledge was also found in terms of factors limiting the supply of iodine from the diet.

This data indicate that most of the pregnant women do not have much information about cruciferous plant, legumes and beverages that contain compounds which may limit the utilization of iodine in the synthesis of thyroid hormones (Baczyk et al., 2006).

4.1.4 Consumption of iodized salt and the correlation with UIC

The data of intake of iodised salt is important for the determination of iodine status since there has been reported that the usage of iodized salt can increase the iodine in the body and decrease the risk of IDDs. According to WHO/ICCIDD/UNICEF (2007), in nearly all regions affected by iodine deficiency, the most effective way to control iodine deficiency is through salt iodization.

Table 4.4: Consumption of iodized salt

Consumption of iodized salt	*Pregnant women (n=100)*	
	N	%
Yes	62	62.0
No	38	38.0

Table 4.4 shows the frequency of user and non-user of iodized salt. In this study, there are high percentage of pregnant women who consumed iodized salt, but the MUIC still low and indicate severe iodine deficiency. This perhaps because of lack of monitoring of iodized salt usage.

The introduction and implementation of Universal Salt Iodization (USI) in Sabah have helped to eradicate the IDD problem effectively based on a consistent optimum level of median UI since its gazettment in 1999 (State Health Department of Sabah, 2008). According to Zimmermann et al. (2004), in IDD-affected areas, cessation of salt iodisation is associated with rapid deterioration of thyroid function in school age children and after five month of discontinuation of salt iodisation, MUIC had dropped to 20 µg/L, and after fourteen months, the rate of goiter was similar to the rate before salt iodisation. Table 4.5 shows the relationship between the consumption of iodized salt and UIC.

Table 4.5: Pearson's correlation coefficient between consumption of iodized salt and UIC.

	UIC (µg/L)	
	R	P
Consumption of iodised salt	-0.59	0.558

From the result, it showed that there is no significant correlation between consumption of iodized salt and UIC. However, in contrast a survey conducted by Rusidah et al. (2010), reported that there was a significant association between consumption of iodised salt among the households and urinary iodine status. There were also a slightly higher number of iodine deficient children residing in households that did not consume iodized salt.

4.1.5 Practises towards iodized salt

Table 4.6 shows the data on the practise handling toward iodized. This handling of iodized salt is important in order to avoid iodine loss during storage and cooking. From the data, most of the pregnant women used iodized salt while almost done cooking. The timing of addition of iodized salt to food being cooked is important for preserving the iodine content. Ideally it should be added at the end of the cooking process, which is contrary to common culinary practices. It has been shown that frying reduces the iodine content by 20%, grilling by 23% and boiling by as much as 58% (WHO, 1996).

From the data, it showed that most of the respondents stored the iodized salt in container with lid and with no exposure to the sun. It is practical because iodine content of salt is known to leach out if exposed to moisture and sunshine.

Table 4.6: Practises toward iodized salt

Handling	*Iodized salt user (n=35)*	
	N	%
Time of iodized salt used during cooking		
Early	1	1.0
In the middle	3	3.0
Almost done	27	27.0
No specific time	4	4.0
Iodized salt storage		
Plastic bag in which the salt was bought	3	3.0
Container with lid	30	30.0
Not sure	2	2.0
Salt exposure to sunlight		
Yes	32	32.0
Not sure	3	3.0

4.2 Biochemical assessment

4.2.1 Urinary iodine concentration assessment

Table 4.7: Urinary iodine concentration assessment of pregnant women

UIC (µg/L)	N	%
Insufficcient (<150)	100	100

From the analysis, if has been found that median urinary iodine concentration is 8.5 µg/L. It showed that the iodine status of the population is severely insufficient. Based on WHO, the iodine status of the population can be considered as normal if the median UIC value is in between 150-249 µg/L.

From the table 4.7, it has been found that 100% of the respondents showed insufficient iodine intake. For the sample that showed UIC less than 150 µg/L, it is in high risk of IDDs (WHO/ICCIDD/UNICEF, 1993). Most of the respondents found to have severe iodine deficiency because the urinary iodine levels were less than 20 µg/L. All of the respondents were at high risk of iodine deficiency because of their urinary iodine concentration falls less than 100 µg/L. Iodine deficiency during pregnancy has been associated with increased incidence of miscarriage, stillbirth, and birth defects. Moreover, severe iodine deficiency during pregnancy may cause congenital hypothyroidism and neurocognitive deficits in the offspring (Food and Nutrition Board, 2001; Levander & Whanger, 1996).

The median urinary iodine (MUIC) of pregnant women in this study, which is 8.5 µg/L was found to be slightly lower that the MUIC of Orang Asli women in childbearing age living near Kuala Lumpur with the MUIC at 14.5 µg/L (Cuthbertson et al., 2000). The MUIC in this study is also lower compared to 78.0 µg/L found among rural antenatal mothers in Bachok, Kelantan (Noran et al., 2005). A national study done in 1995 among school-aged children found the MUIC to be higher at 82.0 μg/L (Loo et al., 1995). Besides, the national study on school children also found that deficiency is was more marked in six states include Kelantan with MUIC at 76.9 μg/L (IDD Newsletter, 2010).

Because of the population in this studies found to be severe iodine deficiency, the iodized salt supplementation program for pregnant women should be continued together with the relevant education. The intake of the iodized salt and practising on iodized salt intake should be monitor in order to ensure that pregnant mother will have adequate iodine level and also to avoid the risk of IDDs.

4.3 Correlation coefficient between socio-demographic variables and UIC

Table 4.8: Correlation coefficient between socio-demographic variables and UIC

	UIC(μg/L)	
	R	P
Race	-0.173	0.086
Age	0.054	0.594
Educational level	0.053	0.602
Occupation	-0.251*	0.012
Household composition	-0.034	0.734
Household income	0.077	0.448
Goiter history	0.041	0.684

*Pearson's correlation is significant at confident level $p<0.05$ (2-tailed)

Table 4.8 showed the correlation coefficient between socio-demographic variables and UIC. It has been found that the employment status has significant correlation with UIC ($r = -0.251$, $p < 0.05$), but only a low correlation, ($r = -0.251$). The relationship was negative linear, which is the higher the employment status, the lower the UIC of respondents. This indicates that people with higher employment status are not necessarily have sufficient iodine intake. They perhaps do not aware of the importance to have sufficient iodine level in the body and do not have much knowledge on IDD, thus make them neglected the need to have sufficient iodine level. In addition, employment status also represents the socio-economic level of the respondents. Because most of the respondents are unemployed, they can be considered in low socio-economic group. Compare to previous study that has been conducted on South African population, it shown that the low socio-economic group was the most vulnerable sector to exposure of iodine deficiency (Jooste et al., 2001). The low socio-economic group also had a lower level of awareness compared to people with a higher socio-economic status (Jooste et al., 2005), thus can lead to have lower iodine intake.

Several studies showed that pregnancy-associated severe iodine deficiency limits ones intellectual capacity, occupational choices, economic development and future earning (Bleichrodt & Born, 1994; Hetzel & Pandav, 1996; Jerome et al., 1986). It is therefore is important for the government to ensure that people have knowledge on iodine and IDDs. Particularly attention should be paid to supply of adequately iodised salt to all socio-economic groups in the population.

4.4 Dietary assessment

Directly assessing the iodine intake of the diet is complex for a number of reasons. In the present study, a qualitative Food Frequency Questionnaire (FFQ) assessed the frequency of consumption, but not the quantity, over the past 3 months, of foods or food groups in diets that are good sources of iodine (Skeaff et al., 2002). Table 4.9 shows the classification of dietary intake based on FFQ score.

Table 4.9: Classification of dietary intake based on FFQ score

Food	FFQ Score	Classification
Saltwater fish	69.42857	Medium
Shellfish	47.28571	Low
Cruciferous vegetables	66.85714	Medium
Cassava	32.14286	Low
Soy product	54.14286	Medium
Tea	47.42857	Low
Coffee	33.14286	Low
Soymilk	65.71429	Medium

Based on Table 4.9, it showed that the intake of the most iodine-rich food, which is seafood, is only in medium. In addition, the intake of the shellfish was reported low. This is maybe due to the high cost of the shellfish that make the population chose to eat other food instead of shellfish. The food that could be goitrogenic and affect the absorption of iodine in the body should be in low intake. But for this population, they have a medium intake for cruciferous vegetables, soy product and soymilk. Other studies of iodine deficiency have indicated the possible interference of iodine absorption by goitrogenic food (Osman et al., 1995; Osman et al., 1992; Delange et al. 1982; Gaitan, 1988). It also has been suggested that goitrogen-consuming communities have even greater iodine requirements, with the daily population requirements doubling from 150 to 300 µg/L.

From previous study that has been conducted by Cuthberson et al. (2000) on Orang Asli community, cassava was found to be a staple food for the study group, which considered as the factors to the iodine deficiency in the population. Orang Asli have high intake of cassava because it can be easily obtained from home gardens and the jungle at no cost. But for this study, pregnant women have low consumption of cassava. It is because the staple food in this population was rice. Besides, it is hard to obtained and need to be bought, not like Orang Asli community that usually get cassava with no cost. A study that has been conducted by Taga et al. (2008), in West-Cameroon, showed that 21% of boys between the ages 3 and 19 were classified as iodine deficient and the prevalence of thiocyanate overload was found to be 20%. The presence of endemic iodine deficiency and excessive thiocyanate in the population indicate that the region is at risk of IDDs (Taga et al., 2008).

4.5 Correlation coefficient between dietary intake and UIC

Table 4.10 showed that there is no significant correlation between dietary intake and UIC. This result was different with the study that has been conducted by Kim et al. (1998), which found to that UIC have positive correlation with the iodine rich dietary intake line seafood, shellfish and milk.

Several studies also showed that there is correlation between intake of goitrogenic substance like soy. Intake of soy may reduce the efficiency of thyroid hormone function and that soybeans may contain goitrogens that can interfere with the utilization of iodine or functioning of the thyroid gland and cause thyroid problem (Chao Wu Xiao, 2008). In contrast, Bitto et al. (2010) suggests that genistein aglycone in soy intake does not significantly increase the risk of clinical or subclinical hypothyroidism at the dose of 54 mg/d.

According to the study conducted by Osman et al. (1992), it had been found there is significant association between the intake of cassava and prevalence of goiter. Another study conducted among 20 volunteers given boiled cassava shoot for two weeks showed a significant goitrogenic effects on the function of thyroxine hormone and triiodothyronine hormone (Osman et al., 1993).

Table 4.10: Correlation coefficient between dietary intake and UIC

	UIC(μg/L)	
	r	p
Saltwater fish	0.077	0.449
Shellfish	0.080	0.429
Cruciferous veg.	0.099	0.329
Cassava	0.074	0.465
Soy product	-0.027	0.788
Soymilk	0.081	0.422
Tea	0.038	0.708
Coffee	0.178	0.076

CHAPTER 5

CONCLUSION

5.1 Conclusion

From the urinary iodine analysis, the median urinary iodine was 8.5 µg/L and it is classified as severe iodine deficiency. It also indicate that the pregnant women in this population are in risk of Iodine Deficiency disorders (IDDs). Possible contributing factors contribute to this IDDs should be the dietary intake that lack of iodine and consumption of iodized salt. Statistical analysis showed that there is a significant correlation between socio-demographic variables of socio-economic and urinary iodine. The result also showed that there is no significant correlation between dietary intake and urinary iodine. The data in this study showed a high percentage of pregnant women who consumed iodized salt. However, there is no significant correlation between consumption of iodized salt with urinary iodine. The iodized salt supplementation program should be implementation in all over the state in order to avoid the risk of IDDs. Health education also should be given to promote adequate iodine intake, as pregnant women are particularly vulnerable to inadequate dietary iodine intake.

5.2 Limitations of the study

The study only does not have wider dimension of the problem because it only cover for the population in Kelantan. Besides, the food frequency questionnaires

(FFQ) are not practical to be used because the respondents tend to give the inaccurate answer because they usually do not remember the frequency of the food they consume. This study also does not specifically done according to urban and rural areas. So, the iodine status of different areas cannot be compared and identified.

5.3 Suggestion for further study

More study should be carried out to determine the iodine status among pregnant women. There are some suggestions for future study. For further study, it is recommended for a wider study location in order to have more accurate and wide dimension of the problem currently occurred. Besides, it is also recommended to use the dietary recall method instead of using food frequency questionnaire (FFQ) in order to get more acceptable and accurate data. It is because sometimes respondents cannot give accurate answer for FFQ. The further study also recommended to further analyze to both urban and rural areas. It is important to study both region in order to compare the iodine status of the population.

5.4 Problem

There is a huge problem in this study whereby the method used to analyse urine iodine concentration is not valid. The published method that has been used in this study is by Husniza, H, Wan Nazaimoon, W.M. 2006. A cost-effective modified micromethod for measuring urine iodine. *Tropical Biomedicine*, 109-115. They have been mistakenly left an important step of 30 minutes incubation following with ceric ammonium addition. Thus the result obtained was very low and all the UIC falls below the category of severely insufficient iodine intake.

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Kod: ____________
Tarikh: ____________

APPENDIX A

UNIVERSITI MALAYSIA TERENGGANU

JABATAN SAINS MAKANAN

FAKULTI AGROTEKNOLOGI DAN SAINS MAKANAN

UNIVERSITI MALAYSIA TERENGGANU

BORANG KAJI SELIDIK

STATUS IODIN DI KALANGAN WANITA MENGANDUNG DI NEGERI KELANTAN

Saya Nur Zezadila Binti Mohamed Zainuzain, UK17614, merupakan pelajar tahun tiga dari Fakulti Agroteknologi dan Sains Makanan (FASM), Universiti Malaysia Terengganu (UMT). Borang kaji selidik ini merupakan salah satu bahagian yang wajib bagi kajian yang telah disebutkan di atas untuk Projek Ilmiah Tahun Akhir (MKN 4199B). Objektif utama kaji selidik ini dijalankan adalah untuk mengkaji status iodin dan kehadiran penyakit gangguan akibat kekurangan iodin (GAKI)/ *Iodine deficiency disorders* (IDDs) serta faktor-faktor yang mempengaruhi masalah tersebut di kalangan wanita mengandung di negeri Kelantan. Kesemua maklumat yang diperoleh adalah sulit dan hanya akan digunakan bagi tujuan kajian ini sahaja.

Terima kasih.

BAHAGIAN A: PROFIL SOSIODEMOGRAFIK DAN LATAR BELAKANG
Bahagian ini adalah penting untuk mendapatkan maklumat peribadi responden. Bahagian ini mengandungi 12 soalan. **Sila tandakan (✓) pada kotak yang telah disediakan.**

1. Bangsa
   - ☐ Melayu ☐ Cina ☐ India ☐Lain-lain:_______ *(sila nyatakan)*
2. Agama
   - ☐ Islam ☐ Kristian ☐ Buddha ☐ Hindu
   - ☐ Lain-lain: __________ *(sila nyatakan)*
3. Umur : ____________ tahun
4. Taraf pendidikan
   - ☐ Tidak bersekolah ☐ Sekolah rendah
   - ☐ Sekolah menengah (PMR/SPM) ☐ Diploma/STPM
   - ☐ Ijazah (Sarjana muda) ☐ Pasca Ijazah (Master/ PhD)
5. Status pekerjaan ibu
   - ☐ Pengawai kanan atau Pengurus
   - ☐ Professional (contoh: doktor, peguam, akauntan, guru dan lain-lain)
   - ☐ Juruteknik dan bidang yang berkaitan
   - ☐ Pekerja perkhidmatan (contoh: pembantu kedai, pelayan restoran, lain-lain)
   - ☐ Pekerja kilang
   - ☐ Perniagaan sendiri
   - ☐ Tidak bekerja/ suri rumah
   - ☐ Pelajar
   - ☐ Lain-lain: __________ *(sila nyatakan)*
6. Jumlah isi rumah (orang) termasuk suami, anak atau yang tinggal bersama
   - ☐ 1 ☐ 2 – 3 ☐ 4 – 5 ☐ 6 – 7 ☐ 8 atau lebih
7. Pendapatan bulanan isi rumah (termasuk suami, isteri dan sesiapa yang bekerja)
   - ☐ Kurang dari RM1,500 ☐ RM4,001- RM5,000
   - ☐ RM1,501- RM3,000 ☐ RM5,001- RM6,000
   - ☐ RM3,001- RM4,000 ☐ RM6,001 dan ke atas

8. Adakah mana-mana ahli keluarga (termasuk datuk, nenek, ibubapa, saudara-mara) anda pernah mengalami penyakit beguk/bengkak pada saraf leher (*goiter*)?

☐ Ya ☐ Tidak ☐ Tidak pasti

9. Adakah anda merokok?

☐ Ya ☐ Tidak ☐ Tidak pasti

10. Berdasarkan jawapan anda di soalan no. 10, jika ***Ya***, berapa purata batang rokok yang anda hisap dalam sehari?

☐ 1- 10 ☐ 11 – 20 ☐ 21 – 30 ☐ 31 dan ke atas ☐ Tidak pasti

11. Adakah suami anda merokok?

☐ Ya ☐ Tidak ☐ Tidak pasti

12. Berdasarkan jawapan anda di soalan no.12, jika ***Ya***, berapa purata batang rokok yang suami anda hisap dalam sehari?

☐ 1- 10 ☐ 11 – 20 ☐ 21 – 30 ☐ 31 dan ke atas ☐ Tidak pasti

BAHAGIAN B: DATA OBSTETRIK

Bahagian ini mengandungi 5 soalan. **Sila tandakan (✓) pada kotak yang telah disediakan.**

1. Usia kandungan sekarang

☐ Trimester pertama *(minggu 1 ke 12)*

☐ Trimester kedua *(minggu 13 ke 28)*

☐ Trimester ketiga *(minggu 29 ke 40)*

2. Bilangan anak

☐ Belum mempunyai anak ☐ 2 – 3 ☐ 6 – 7

☐ 1 ☐ 4 – 5 ☐ 8 atau lebih

3. Bilangan kali mengandung termasuk yang sekarang (*Gravida*)

☐ 1 ☐ 2 – 3 ☐ 4 – 5 ☐ 6 – 7 ☐ 8 atau lebih

4. Bilangan kali melahirkan anak termasuk yang hidup dan yang meninggal semasa lahir (*Parity*)

☐ 1 ☐ 4 – 5 ☐ 8 atau lebih

☐ 2 – 3 ☐ 6 – 7 ☐ Tidak pernah melahirkan

5. Berapa kali anda pernah keguguran?

☐ 1 ☐ 4 – 5 ☐ 8 atau lebih

☐ 2 – 3 ☐ 6 – 7 ☐ Tidak pernah

BAHAGIAN C: PENGETAHUAN TENTANG IODIN DAN PENYAKIT GANGGUAN KEKURANGAN IODIN/ IODINE DEFICIENCY DISORDERS (IDDS)

Bahagian ini mengandungi 11 soalan.
Sila tandakan (✓) pada kotak yang telah disediakan.

1. Pada pendapat anda, yang manakah paling tepat untuk menyatakan apakah iodin?
   - ☐ Vitamin
   - ☐ Sesuatu bahan yang terdapat dalam makanan *yang dimakan*
   - ☐ Mineral
   - ☐ Lain-lain, sila nyatakan: ____________
   - ☐ Mikronutrien
   - ☐ Tidak tahu

2. Bahagian badan yang manakah memerlukan iodin untuk berfungsi?
   - ☐ Kelenjar tiroid/ kelenjar di bahagian leher
   - ☐ Lain-lain, sila nyatakan: ____________
   - ☐ Tidak tahu

3. Di antara makanan berikut, yang manakah mengandungi sumber iodin yang utama?
   - ☐ *Ikan/ makanan laut/ produk yang dihasilkan daripada makanan laut*
   - ☐ Sayur- sayuran
   - ☐ Daging/ produk yang dihasilkan daripada daging
   - ☐ Produk tenusu seperti susu/ keju/ mentega
   - ☐ Air minuman
   - ☐ Garam beriodin
   - ☐ Lain-lain, sila nyatakan: ____________
   - ☐ Tidak tahu
   - ☐ Tidak tahu apa itu iodin

4. Adakah makanan di bawah merupakan sumber iodin yang baik?

Makanan	**Ya**	**Tidak**	**Tidak tahu**
Daging			
Susu			
Roti			
Ikan dan makanan laut			
Buah-buahan			
Sayur-sayuran			
Telur			
Garam beriodin			

5. Pernyataan berikut adalah tentang pendapat anda berkaitan dengan fungsi iodin untuk manusia dan sumbernya di dalam makanan.
Sila bulatkan jawapan anda untuk menunjukkan kesetujuan / ketidaksetujuan anda.

	Sangat tidak setuju	Agak tidak setuju	Neutral	Agak setuju	Sangat setuju
Iodin boleh didapati di dalam air minuman biasa	1	2	3	4	5
Kandungan iodin di dalam ikan laut lebih tinggi berbanding ikan air tawar.	1	2	3	4	5
Kandungan iodin yang paling tinggi terdapat pada ikan air tawar	1	2	3	4	5

6. Pernyataan berikut adalah tentang faktor yang mempengaruhi bekalan iodin di dalam pemakanan.
Sila bulatkan jawapan anda untuk menunjukkan kesetujuan / ketidaksetujuan anda.

	Sangat tidak setuju	Agak tidak setuju	Neutral	Agak setuju	Sangat setuju
Pengambilan kopi dan teh dalam kuantiti yang banyak tidak akan mempengaruhi penyerapan iodin.	1	2	3	4	5
Makan sayur-sayuran *cruciferous* (kubis, bunga kubis) tidak akan memberikan kesan kepada keseimbangan iodin di dalam badan.	1	2	3	4	5
Sayur-sayuran *cruciferous* (kubis, bunga kubis) mempercepatkan penyerapan iodin.	1	2	3	4	5
Cara memasak tidak mempengaruhi kehilangan iodin semasa penyediaan makanan.	1	2	3	4	5
Pengambilan soya dan kacang boleh merendahkan penyerapan iodin di dalam badan.	1	2	3	4	5

7. Adakah anda pernah mendengar tentang penyakit gangguan akibat kekurangan iodin (*Iodine deficiency disorders-IDDs*)?

☐ Ya

☐ Tidak

☐ Tidak pasti

8. Berdasarkan soalan no.7, jika *Ya*, dari manakah anda mendapat maklumat tentang penyakit gangguan akibat kekurangan iodin (GAKI) / *Iodine deficiency disorders (IDDs)*? **Jawapan anda boleh melebihi daripada satu.**

- ☐ Surat khabar
- ☐ Buku
- ☐ Jurnal
- ☐ TV / Radio/ Internet
- ☐ Doktor
- ☐ Pakar pemakanan
- ☐ Ahli keluarga
- ☐ Kawan-kawan
- ☐ Kempen
- ☐ Lain-lain (sila nyatakan): ______________

9. Pada pendapat anda, apakah kesan paling berbahaya terhadap kesihatan kanak-kanak sekiranya mereka tidak mendapat iodin yang mencukupi daripada makanan yang mereka makan?

- ☐ Membantut/ memperlahankan tumbesaran
- ☐ Beguk / kelenjar tiroid membesar/ bengkak pada leher
- ☐ Kerosakan pada otak
- ☐ Kecacatan pada anggota badan dan otak (*cretinisme*)
- ☐ Kepekatan hormon tiroid yang rendah di dalam darah (*hypothyroidism*)
- ☐ Kematian
- ☐ Lain-lain (sila nyatakan): ______________
- ☐ Tidak tahu

10. Apakah cara yang sesuai untuk mengurus penyakit gangguan akibat kekurangan iodin (GAKI) / *Iodine deficiency disorders (IDDs)*?

- ☐ Hospital (pembedahan)
- ☐ Rawatan tradisional
- ☐ Lain-lain (sila nyatakan): ______________
- ☐ Rawatan sendiri
- ☐ Garam beriodin
- ☐ Tidak tahu

BAHAGIAN D: PENGETAHUAN, AMALAN DAN SIKAP RESPONDEN TERHADAP PENGAMBILAN GARAM BERIODIN

Bahagian ini mengandungi 6 soalan.
Hanya pengguna garam beriodin sahaja yang perlu menjawab semua soalan dalam bahagian ini. Untuk yang tidak menggunakan garam beriodin, anda hanya perlu menjawab soalan 1, 2 dan 6 sahaja.
Sila tandakan (✓) pada kotak yang disediakan.

1. Adakah anda pernah mendengar tentang garam beriodin?

☐ Ya ☐ Tidak ☐ Tidak pasti

2. Adakah anda menggunakan garam beriodin?

☐ Ya ☐ Tidak ☐ Tidak pasti

Berdasarkan jawapan anda di soalan no.2,

- **Jika YA, teruskan ke soalan seterusnya sehingga soalan 6.**
- **Jika TIDAK dan TIDAK PASTI abaikan soalan 3, 4, 5 dan teruskan ke soalan 6.**

3. Semasa memasak, garam beriodin dimasukkan ketika
   - ☐ Mula-mula memasak
   - ☐ Di tengah-tengah waktu memasak
   - ☐ Hampir siap memasak
   - ☐ Tiada masa yang tetap
   - ☐ Tidak pasti

4. Di dalam bekas bagaimanakah anda menyimpan garam beriodin?
   - ☐ Beg plastik asal bagi garam beriodin
   - ☐ Kotak kayu
   - ☐ Bekas dengan lubang di bahagian atas
   - ☐ Bekas tanpa penutup
   - ☐ Bekas dengan penutup
   - ☐ Lain-lain, sila nyatakan: ______________
   - ☐ Tidak pasti

5. Adakah garam beriodin yang disimpan terdedah kepada cahaya matahari?
   - ☐ Ya
   - ☐ Tidak
   - ☐ Tidak pasti

6. Penyataan berikut adalah tentang pendapat anda terhadap pengambilan garam beriodin. **Sila bulatkan jawapan anda untuk menunjukkan kesetujuan / ketidaksetujuan anda.**

	Sangat tidak setuju	Agak tidak setuju	Neutral	Agak setuju	Sangat setuju
Saya percaya bahawa makanan yang disediakan dengan menggunakan garam beriodin kurang sedap berbanding makanan yang menggunakan garam biasa.	1	2	3	4	5
Saya percaya bahawa harga garam beriodin adalah mahal dan tidak setimpal dengan manfaat yang diperolehi.	1	2	3	4	5
Saya percaya bahawa ada baiknya memberikan garam beriodin kepada kanak-kanak.	1	2	3	4	5
Saya percaya bahawa garam beriodin perlu dikendalikan dengan baik samada di gudang ataupun di rumah berbanding dengan garam biasa.	1	2	3	4	5
Saya percaya bahawa perlu untuk saya menasihatkan ahli keluarga saya untuk menggunakan garam beriodin.	1	2	3	4	5
Saya percaya bahawa lebih baik menggunakan garam beriodin berbanding garam biasa.	1	2	3	4	5

BAHAGIAN E: AMALAN PEMAKANAN DAN PENGAMBILAN SUPPLEMEN TAMBAHAN

Bahagian ini mengandungi 5 soalan. **Sila tandakan (✓) pada kotak yang telah disediakan.**

1. Apakah cara penyediaan makanan yang selalu digunakan untuk memasak sayur-sayuran
   - ☐ Menggoreng
   - ☐ Membakar
   - ☐ Mengukus
   - ☐ Merebus

2. Apakah cara penyediaan makanan yang selalu digunakan untuk memasak ikan
   - ☐ Menggoreng
   - ☐ Membakar
   - ☐ Mengukus
   - ☐ Merebus

3. Pengambilan multi vitamin yang mengandungi iodin

☐ Ya ☐ Tidak ☐ Tidak pasti

4. Pengambilan suplemen potassium iodin

☐ Ya ☐ Tidak ☐ Tidak pasti

5. Berapa kerapkah anda mengambil makanan dan minuman yang dinyatakan? **Sila tandakan (✓) pada kotak yang telah disediakan.**
K= Saiz Kecil S= Saiz Sederhana B= Saiz Besar

Kekerapan/saiz hidangan / **Jenis makanan/minuman**	Tidak pernah/ <1x/bulan	1-3x/bln	1x/ Minggu	2-4x/ minggu	5-6x/ minggu	1x/ hari	> 1x /hari	Saiz hidangan sederhana	K	S	B
Makanan											
Bijirin (contoh: nasi, mee, oat)								1 cawan			
Sayur-sayuran (contoh:sayuran berdaun hijau, lobak merah)								½ cawan			
Sayuran *cruciferae*(contoh: kubis, bunga kubis, brokoli)								½ cawan			
Ubi (contoh: ubi kayu, ubi keledek)								1 sederhana			
Buah-buahan (contoh: pisang, epal, mangga)								1 sederhana			
Legum (contoh: kacang buncis, pea, dhal)								½ cawan			
Kekacang (contoh: kacang gajus, kacang tanah)								2 tbs (sudu besar)			
Soya dan produk daripada soya (tempeh, tau fu fa)								1 cawan			
Daging putih (contoh: paha ayam)								2 ketul kecil			
Daging merah (contoh:kambing, lembu)								1 senduk			
Ikan laut dalam (contoh: kerisi, kembong, selar kuning)								1 ekor sederhana			
Ikan air tawar (contoh: keli, tilapia, patin)								1 ekor sederhana			
Kekerang (contoh: ketam, udang, sotong, remis)								1 senduk			
Tenusu (contoh: susu, yogurt, keju)								1 cawan			
Telur								2 telur			
Lemak (contoh: keju, marjerin) dan minyak masak								2 tsp (sudu teh)			
Biskut/kek/kuih								6 keping			
Makanan terproses segera (contoh: sup cendawan segera)								1 paket			
Makanan segera (contoh: McDonald, Pizza Hut)								Rujuk menu			
Makanan berkaleng (contoh: sardin, tuna, kacang panggang)								½ tin			
Makanan diproses (contoh: sosej, nuget)								2 sosej			
Makanan ringan (contoh: gula-gula, kerepek kentang)								2 genggam			
Minuman											
Susu								1 cawan			
Susu soya								1 cawan			
Kopi								1 cawan			
Latte, cappuccino, mocha atau coklat panas								1 cawan			
The								1 cawan			
Jus buah sebenar (100%)								¾ cawan			
Jus buah komersial (dengan gula tambahan dan pengawet)								¾ cawan			
Minuman ringan (contoh: root beer, coca-cola)								1 tin			

BAHAGIAN F : ANTHROPOMETRY DATA

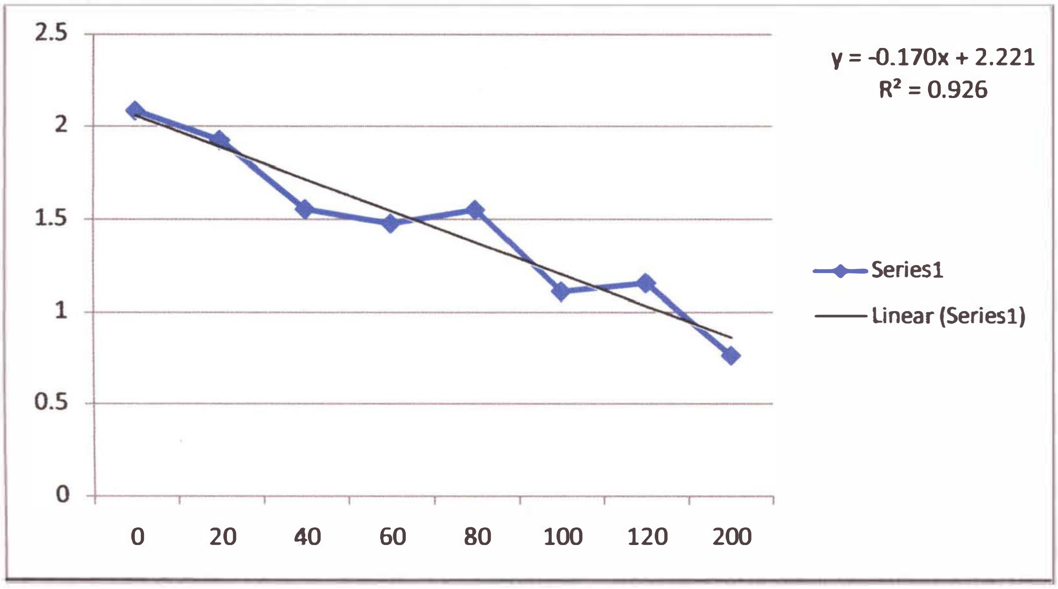
1. **Berat : _______________kg**
2. **Tinggi : _______________m**

TERIMA KASIH!

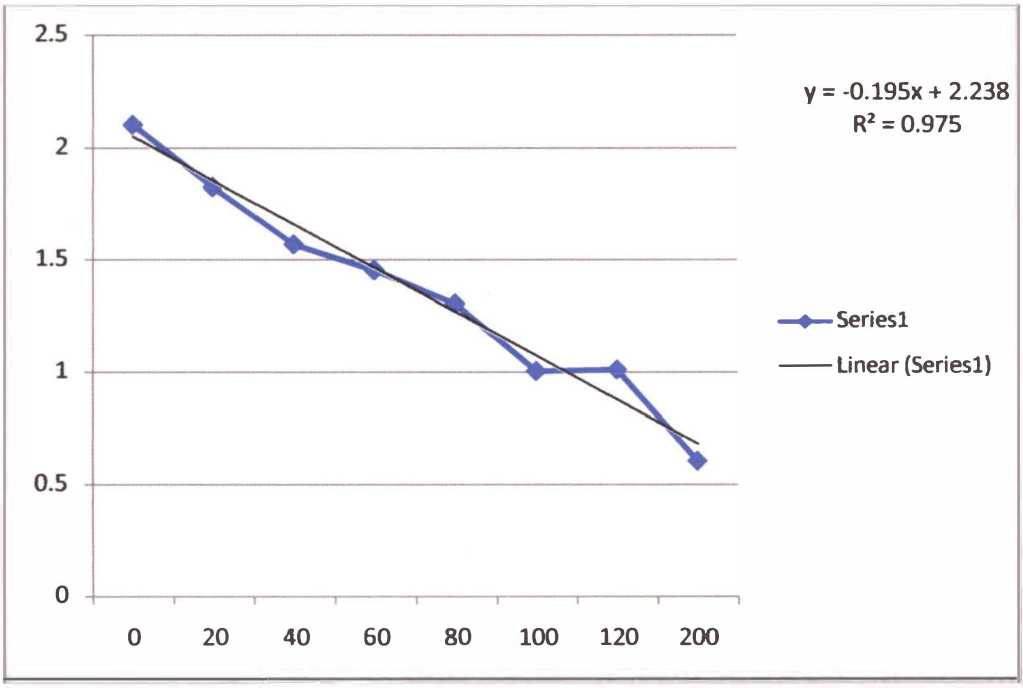
Sila ambil sedikit masa dan pastikan anda telah menjawab setiap soalan yang telah diberikan.

APPENDIX B

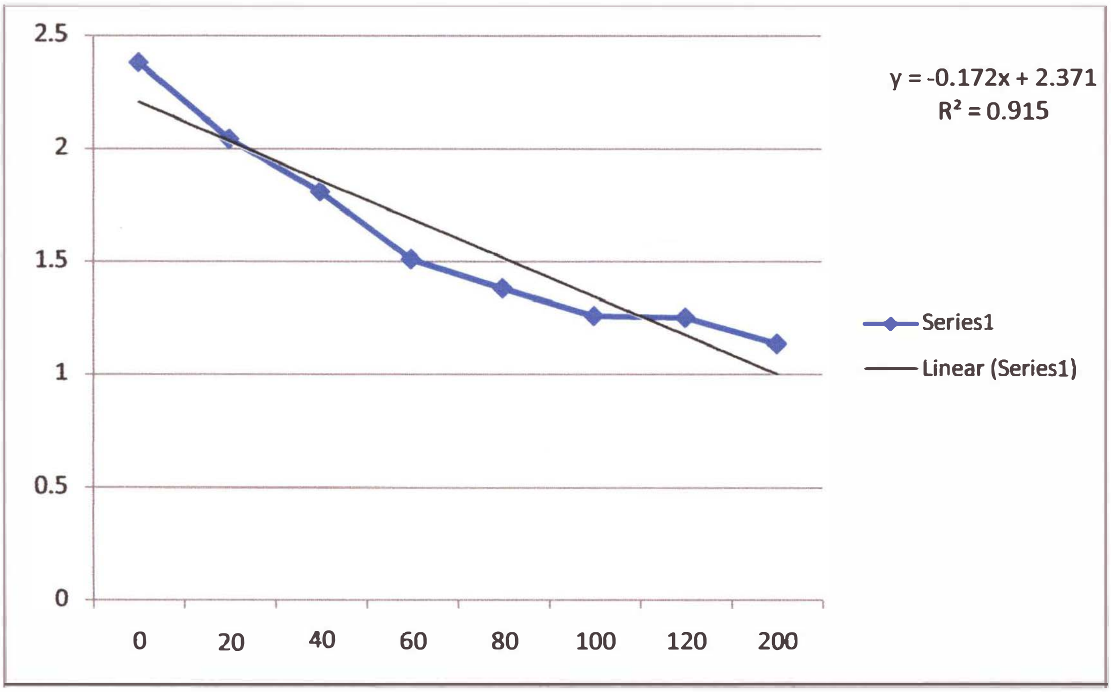
Determination of urinary iodine concentration
Standard curve for iodine measurement using modified micromethod



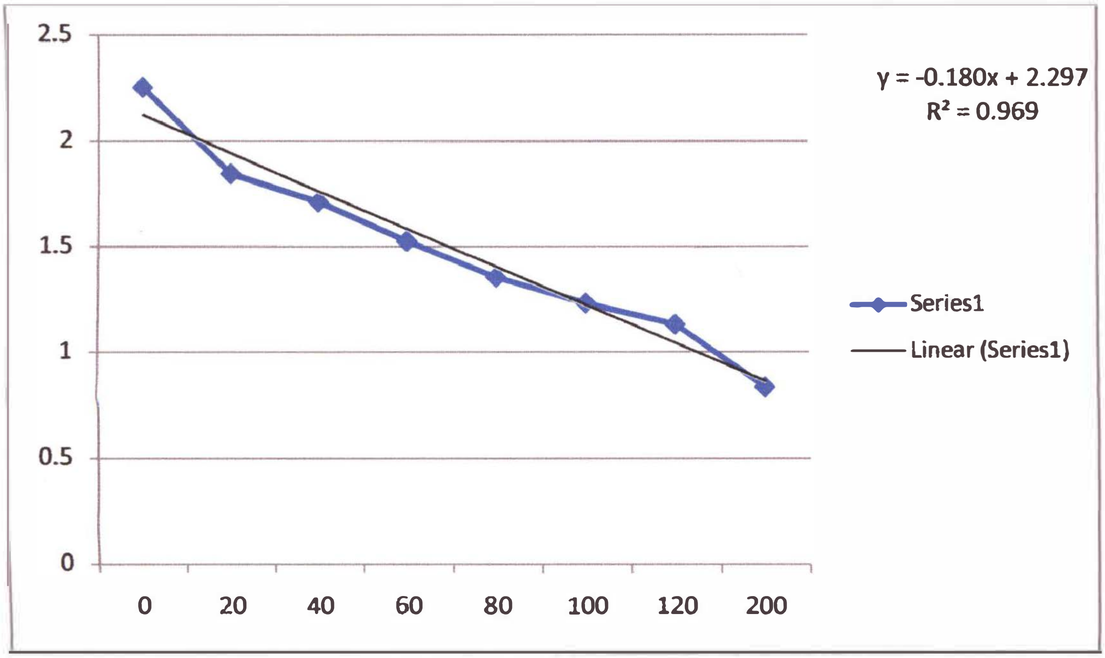
	R1	R2	Average	x value
A1	1.37737	1.43052	1.403945	24.03103
A2	1.86255	1.89657	1.87956	10.04235
A3	1.85216	1.94197	1.897065	9.5275
A4	1.71354	1.62101	1.667275	16.28603
A5	1.92958	1.84333	1.886455	9.839559
A6	1.88185	1.77963	1.83074	11.47824
A7	1.75427	1.94323	1.84875	10.94853
A8	1.77796	1.72289	1.750425	13.84044
A9	1.83548	1.67923	1.757355	13.63662
A10	1.92495	1.93177	1.92836	8.607059
A11	1.8314	1.7856	1.8085	12.13235
A12	1.7442	1.78646	1.76533	13.40206
A13	1.89517	1.74832	1.821745	11.74279
A14	1.85771	1.79859	1.82815	11.55441
A15	1.75911	1.7374	1.748255	13.90426
A16	1.76867	1.75979	1.76423	13.43441
A17	1.84757	1.68498	1.766275	13.37426
A18	1.50703	1.83767	1.67235	16.13676
A19	1.87495	1.85837	1.86666	10.42176
A20	1.81187	1.69298	1.752425	13.78162



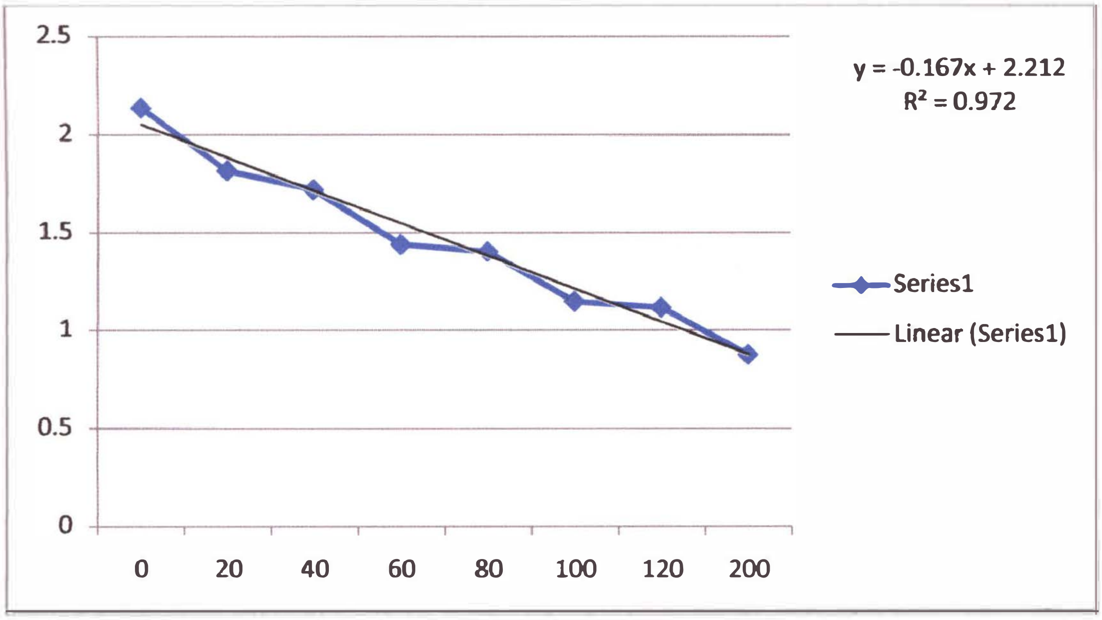
	R1	R2	Average	x value
B1	2.03744	2.02821	2.032825	5.260897
B2	1.42104	1.76582	1.59343	16.52744
B3	2.00942	1.99405	2.001735	6.058077
B4	1.87629	1.75747	1.81688	10.79795
B5	1.95509	1.75738	1.856235	9.788846
B6	2.01488	2.00064	2.00776	5.90359
B7	1.95368	1.91459	1.934135	7.79141
B8	1.92123	2.07412	1.997675	6.162179
B9	2.07172	1.49944	1.78558	11.60051
B10	1.948	1.95398	1.95099	7.359231
B11	1.87088	1.58646	1.72867	13.05974
B12	1.63449	1.86173	1.74811	12.56128
B13	1.80382	1.72393	1.763875	12.15705
B14	1.33427	1.37635	1.35531	22.63308
B15	0.589744	1.80727	1.198507	26.65367
B16	1.70385	1.81101	1.75743	12.32231
B17	1.4939	1.85892	1.67641	14.39974



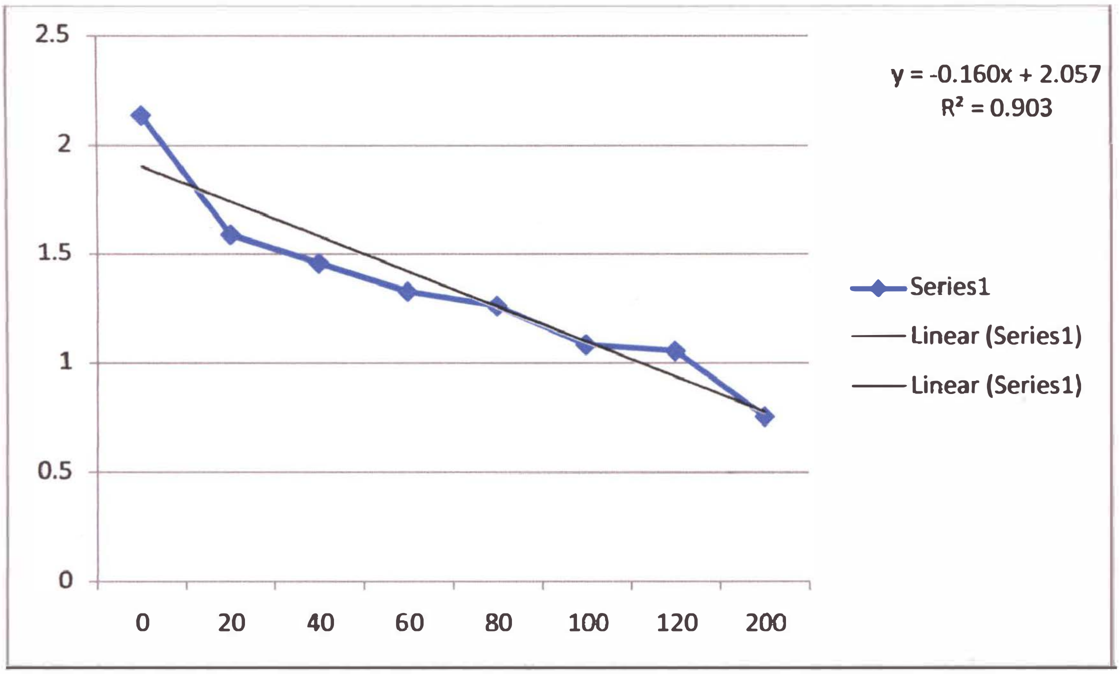
	R1	R2	Average	x value
C1	2.58487	2.03326	2.309065	1.800436
C20	2.15461	2.14537	2.14999	6.424709
C3	2.32695	2.2299	2.278425	2.691134
C4	2.43174	2.31538	2.37356	-0.07442
C5	2.18404	1.8499	2.01697	10.29157
C6	2.16014	2.30263	2.231385	4.058576
C7	2.16808	2.40299	2.285535	2.484448
C8	2.23126	2.18198	2.20662	4.778488
C9	2.59207	2.01327	2.30267	1.986337
C10	2.15725	1.95422	2.055735	9.16468
C11	2.08172	1.71944	1.90058	13.675
C12	1.87954	2.04736	1.96345	11.84738
C13	2.18413	2.21647	2.2003	4.962209



	R1	R2	Average	x value
D1	2.16976	2.14774	2.15875	3.840278
D2	1.98403	2.18055	2.08229	5.964167
D3	2.21715	2.05223	2.13469	4.508611
D4	2.26759	2.21778	2.242685	1.50875
D5	2.21746	2.21064	2.21405	2.304167
D6	2.13379	2.14044	2.137115	4.44125
D7	2.06897	1.97114	2.020055	7.692917
D8	2.00588	1.94641	1.976145	8.912639
D9	2.03364	2.13027	2.081955	5.973472
D10	1.89413	1.90469	1.89941	11.04417
D11	1.97734	1.81608	1.89671	11.11917
D12	2.19578	2.07644	2.13611	4.469167
D13	2.01233	2.00069	2.00651	8.069167
D14	2.22887	2.15812	2.193495	2.875139
D15	2.15714	2.11976	2.13845	4.404167
D16	1.93561	1.77144	1.853525	12.31875
D17	1.68541	1.58335	1.63438	18.40611
D18	1.73648	1.27247	1.504475	22.01458
D19	1.3772	2.23783	1.807515	13.59681



	R1	R2	Average	x value
E1	1.86942	1.90857	1.888995	9.670808
E2	1.90973	1.8746	1.892165	9.575898
E3	1.69365	1.7782	1.735925	14.25374
E4	1.91093	1.99537	1.95315	7.75
E5	1.83393	1.76998	1.801955	12.2768
E6	1.94064	1.97305	1.956845	7.639371
E7	1.72901	1.66294	1.695975	15.44985
E8	1.89336	1.86374	1.87855	9.983533
E9	2.01695	1.98001	1.99848	6.392814
E10	1.92524	1.99449	1.959865	7.548952
E11	2.06835	1.8684	1.968375	7.294162
E12	1.93743	1.91923	1.92833	8.493114
E13	1.91819	1.95456	1.936375	8.252246
E14	1.87937	1.8701	1.874735	10.09775
E15	1.93498	1.96887	1.951925	7.786677
E16	1.98225	1.79945	1.89085	9.615269
E17	1.68028	1.71219	1.696235	15.44207
E18	1.66771	1.90081	1.78426	12.80659
E19	1.7579	1.83147	1.794685	12.49446



	R1	R2	Average	x value
F1	1.83246	1.74634	1.7894	1.6725
F2	1.89192	1.80081	1.846365	1.316469
F3	1.63487	1.76846	1.701665	2.220844
F4	1.94831	1.62876	1.788535	1.677906
F5	1.98727	2.01638	2.001825	0.344844
F6	1.93716	1.98011	1.958635	0.614781
F7	1.59781	1.54995	1.57388	3.0195
F8	1.962	1.92617	1.944085	0.705719
F9	1.9568	2.0743	2.01555	0.259062
F10	1.85516	1.98485	1.920005	0.856219
F11	1.97818	1.94249	1.960335	0.604156
F12	1.88651	1.88254	1.884525	1.077969
F13	2.09242	2.14279	2.117605	-0.37878
F14	2.02365	1.93466	1.979155	0.486531
F15	1.7449	1.76343	1.754165	1.892719
F16	2.09843	1.85094	1.974685	0.514469
F17	1.81734	1.70707	1.762205	1.842469
F18	1.46801	1.60803	1.53802	3.243625

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IODINE STATUS AMONG PREGNANT WOMEN IN KELANTAN - NUR ZEZADILA BINTI MOHAMED ZAINUZAIN