IODINE STATUS OF PREGNANT AND LACTATING WOMEN IN ARUSHA MUNICIPALITY

BY

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ABSTRACT

A cross-sectional study was carried out to determine iodine status of pregnant and lactating women in Arusha Municipality. Urine and salt samples were collected from a total of 429 respondents who were visiting Themi and Ngarenaro Reproductive and Child Care clinics. A structured questionnaire was used to collect socio-economic and demographic information from respondents and also wholesale and retail salt traders to ascertain their knowledge about iodised salt and IDD. Results revealed that, overall median UIC for pregnant women (33%) was 205 µg/l (95% CI; 26.7%, 39.2%), and lactating women (22.8%) was 155.5 µg/l (95% CI; 17.1%, 28.4%). Median UIC for pregnant women (62.9%) in Themi was 122 µg/l (95% CI; 46.6%, 79%), while median UIC for lactating women (28.2%) was 178.1 µg/l (95% CI; 20.8%, 35.5%). The median UIC for pregnant women (36.5%) at Ngarenaro was 233.9 µg/l (95% CI; 29.5%, 43.4%), while median UIC for lactating women (39.2%) was 123.5µg/l (95% CI; 27.6%, 50.7%). The recommended UIC for pregnant and lactating women range of 150-249 µg/l indicate adequate iodine intake. These results suggested that, those pregnant women from Themi ward had mild iodine deficiency while the lactating women had optimal iodine intake. Pregnant women from Ngarenaro ward had adequate iodine intake while for lactating women had mild iodine deficiency. About 34% (95% CI; 23%, 44%) of pregnant women had UIC above recommended safety levels of >500 µg/l which suggested that, pregnant women might have excessive iodine intake. Likewise, 15% (95% CI; 3%, 33%) of lactating women had UIC levels above the recommended levels of >500 µg/l suggesting that, lactating women could also be taking excessive iodine. Excessive intake iodine could be due to increased iodine intake from foods due to high levels of

iodine in salt used in cooking. It was concluded from the study that, most respondents had adequate iodine intake. However, 34% and 15% of pregnant and lactating women, respectively, had excessive iodine intake. There is a need to re-examine iodation levels to comply with the WHO recommended levels of 40 ppm at factory. Further studies involving large population groups should be done to ascertain the looming risk of iodine toxicity among pregnant and lactating women.

DECLARATION

I, ROSELINE MAREALLE, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has neither been submitted nor been concurrently submitted for a similar degree award in any other University.

ROSELINE MAREALLE	Date
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The above declaration is confirmed

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This work is dedicated to my beloved and precious son Samuel F. Kileo.

LIST OF ABBREVIATIONS

CI	Confidence level
FAO	Food and Agriculture Organization of the United Nations
IDD	Iodine Deficiency Disorders
ICCIDD	International Council for Control of Iodine Deficiency Disorders
µg/l	Micro gram per litre
ppm	Parts Per Million
RNI	Recommended Nutrient Intake
TFNC	Tanzania Food and Nutrition Centre
TFDA	Tanzania Food and Drug Authority
TSH	Thyroid stimulating hormone
T_3	Tri-iodothyronine
T_4	Tetra-iodothyronine (Thyroxine)
UNICEF	United Nations Children’s Fund
USI	Universal Salt Iodation
UIC	Urinary Iodine Concentration
WHO	World Health Organization
WHA	World Health Assembly

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Iodine deficiency disorders impair growth, development, and intellectual capacity, and contribute to reproductive problems in women. IDD affects an estimated 655 million people worldwide, and 915 million people live in areas that put them at risk for IDD. Iodine is an essential micronutrient and component of thyroid hormones, thyroxine (T4) and triiodothyronine (T3), which influence skeletal maturation, development of the central nervous system and regulate many other physiological processes such as body metabolism of carbohydrate, protein, vitamin and mineral in humans (WHO/FAO, 1998). Iodine deficiency in humans is usually characterized by low levels of T4 and high levels of thyroid-stimulating hormone (TSH). The body of healthy human adult contains 15-20 mg of iodine of which 70-80% is stored in thyroid gland. Both low and high iodine intake levels may lead to disease. This is particularly observed in the fetus, where, on one hand, severe iodine deficiency of the mother may lead to insufficient thyroid hormone synthesis in both the mother and fetus (Delange, 1999). This may further lead to poor development of brain and physical body growth. On the other hand, excessive iodine given to the mother may block thyroid function in the fetus, leading to hypothyroidism and goiter (Delange *et al.*, 2002).

Iodine deficiency disorders (IDDs) refer to a wide range of health problems associated with iodine deficiency in a population. These health problems include goitre, stillbirth, stunted growth (cretinism), and mental defects (impaired neurocognitive development). These problems are preventable by ensuring adequate intake of iodine (Bruno *et al.,* 2007). Pregnant women and young children living in IDD endemic areas are particularly at risk. Iodine deficiency is the greatest single preventable cause of intellectual impairment in the world today. It is a significant health problem in 118 countries (WHO, 2008). In 1990 World Health Assembly Resolution endorsed the goal of eliminating IDD as a public health problem. In 1993, WHO/UNICEF/ ICCIDD (1993) recommended universal salt iodization as the main strategy to achieve elimination of IDD. This is the most cost effective intervention to correct IDD. Tanzania has adopted USI since the early 1990, but no evaluation of its impact on the population has ever been done.

WHO has recommended salt iodine level of 20-40 ppm. This level of iodation is adequate to meet daily requirement of 150-200 μg iodine per person for adults (ICCIDD/WHO/UNICEF, 1996). Excess or inadequate iodine intake results in a wide spectrum of disorders that may be addressed by adjusting iodine intake. Excessive iodine can result in toxicity. In high-risk areas, iodized oil is recommended for the most vulnerable groups such as pregnant women and young children. Iodine of maternal origin is required for brain development of the progeny during fetal and early postnatal life. Therefore, iodine requirement of the mother is slightly high during pregnancy and lactation (WHO/UNICEF/ICCIDD, 1996). The Technical Consultation Commettee of WHO proposed to increase the current WHO/FAO (2008) recommended nutrient intake for iodine during pregnancy from 200 to 250 μg (Anderson *et al.,* 2007).

The great progress in the fight against iodine deficiency during the last two decades has primarily been the results of an aggressive push for use of iodized salt. As published by UNICEF (1996), while in 1990 only 17% of households worldwide were consuming iodized salt, by 2006 the proportion had increased to about 73% (WHO/UNICEF/ICCIDD, 1996). It must be noted, however, that despite the great progress, almost 30% of the world's population is still struggling with substandard iodine nutrition. One of the reasons for this situation is that neither the proportion of households consuming iodized salt nor the quality of the iodized salt is the same in all countries. The analysis of the data collected from different countries shows that only in 41 countries are more than 90 percent of households actually consuming adequate amounts of iodized salt, as recommended by WHO (Pretell, 2010).

This comparative analysis very clearly shows that the changes in iodine intake between these two periods 2004-2009 has resulted in a dramatic 42% fall in the number of countries with iodine deficiency. But, interestingly, it also shows an increase of 55% in the number of countries classified by the WHO as going beyond the intake requirements. This change from insufficient to above required iodine intake could be considered beneficial rather than risky for those who are at risk of IDD, taking into consideration the higher requirements of iodine intake for pregnant and lactating women. Further analysis and a review of the WHO´s classification is needed (Pretell, 2010). On the other hand the increase in iodine intake and, consequently, the higher proportion of median urinary iodine values observed in the period 2004-2009, took place in almost all regions, although more markedly in Africa, the Americas and Asia. Whether this phenomenon represents a risk of excess iodine for the general population or not requires further investigation. The increase in iodine intake has also resulted in an increased number of countries like Kenya, Niger, Zimbabwe, and Cameroon with iodine intake above the WHO requirements. The implications of this situation also need further evaluation. An increase in iodine intake in populations with chronic iodine deficiency might precipitate iodine induced hyperthyroidism. Iodine-induced hyperthyroidism has been reported in the introductory phase of several universal salt-iodisation programmes, including in Zimbabwe and the Democratic Republic of the Congo due to excessively iodised salt (Delange, 1999). A more important issue is whether some level of chronic iodine intake is harmful. Some classifications of iodine nutrition include categories of high or excessive iodine intake, because high levels of iodine intake have been associated with an increased risk of hyperthyroidism, hypothyroidism, or autoimmune thyroiditis. Indeed, fear of iodine-induced thyroid dysfunction has at times delayed or limited the implementation of iodine supplementation in regions with iodine deficiency. The divergent effects of such supplementation on thyroid disorders may be related to underlying thyroid auto-immune or genetic susceptibility to the disorders. The evidence for the increased risks is based largely on the results of cross-sectional studies before and after iodine intake (Pearce, 2002).

Milligram or higher doses of iodine may cause hypothyroidism in people with damaged thyroid glands and normalization of thyroid secretion in those with hyperthyroidism. This antithyroid action of iodine is often short-lived, owing to down-regulation of iodine transport into the thyroid gland. Conversely, iodine in large quantities may induce hyperthyroidism in patients with a multinodular goiter or

Graves' disease whose iodine intake is low, although it is unlikely to do so if the deficiency is not severe and if the increase in intake is relatively small (Pearce, 2002).

1.2 Problem Statement

Data from the WHO (2007) global database show that 54, countries worldwide have populations with insufficient iodine intake as indicated by the median urine iodine concentration below 50 µg/l. Of the 54 countries, 14 are in the African region. In some countries, there has been an increase in the incidence of hyperthyroidism in susceptible individuals after the introduction of salt iodization. Many salt-producing countries have numerous small-scale salt producers whose operations are often difficult to control. Consequently, there is a wide variation in the iodine levels of iodized salt and salt purity. Salt regulations in Tanzania requires that, all salt meant for human consumption be iodated at 75-100 ppm, at factory level and should not contain less than 37.5 ppm iodine at its point of wholesale or retail (range 37.5-100 ppm). The iodine levels was set at this range to cover about 50% expected losses during transportation, storage and utilization processes before reaching the consumer (URT, 1994; WHO/UNICEF/ICCIDD, 1996). However, the iodine content at factory level has been recently revised and is now 40-80 ppm (TFDA Cap 219 (Iodated Salt) Regulations, 2010).

Due to improvement in technology, infrastructure and transportation, the market chains have become faster and more efficient, the iodine level that was anticipated to decline due to inefficient market chains no longer occurs. Therefore, salt reaches the consumer with very high iodine content, this puts the consumers at a risk of consuming excessive amount of iodine which can lead to health problems and probably toxicity. Processing, packaging and better handling of salt along the market chains have also improved, which contribute to high retention of iodine in salt by the time it reaches the consumer. Consequently, consumers take iodine above the 20-40 ppm recommended by (WHO, 2007). Urinary iodine concentration is a good and reliable biomarker for iodine status. The current recommendations by WHO (2007) for daily iodine intake are 90 µg for infants, 90 to 150 µg for children, 150 µg for adults and 250 µg for pregnant and lactating women. During pregnancy, a median UIC of <150 µg/l indicates insufficient iodine intake, UIC of 150-249 µg/L indicates adequate intake, UIC of 250-499 µg/l implies that intake is more than adequate and UIC of 500 µg/l or higher indicates excessive iodine intake. For pregnant and lactating women the recommended daily intake of iodine is 250 µg/day (WHO, 2007). Some studies in Tanzania (Assey *et al*., 2007) have shown high UIC above 300 µg/l in some social groups. This gives rise to the concern that there could be excessive iodine intake due to improved market chains, salt handling and transportation methods. About 35% of urine sample analysed for urinary iodine concentration at Tanzania Food and Nutrition Centre indicated excess iodine intake (UIC ≥300 µg/l) (Assey *et al*., 2007). An excess iodine intake has also been reported in other countries in Eastern and Southern African (Vicent, 2009). The percentage of individuals with high UIC levels (>300 µg/l) was on the increase in mainland Tanzania, raising a concern of possible of iodine-induced hyperthyroidism in some sectors of populations. In Arusha region, most of people prefers to eat roasted meat spiced with iodated salt, soup and bakery foods are very popular. They also prefer to use iodated salt from Kenya which has been reported to have high iodine content, this iodated salt is highly received in Arusha. The results of this study will help to evaluate suitability of the recently approved limits for iodine in salt for human consumption in Tanzania

1.3 Problem Justification

Despite the efforts to eliminate iodine deficiency disorders, iodine deficiency remains a challenge as there is still a problem of IDD and also excessive intake of iodine in some social groups of the population. Manifestation of excess iodine intake includes thyroiditis, goiter, hypothyroidism, hyperthyroidism and sensitivity reaction. The most susceptible social groups for iodine toxicity are pregnant and lactating women. Exposure to excess iodine during pregnancy may lead to transient hypothyroidism in neonates. Fetal goiter may also occur and in rare instances can give rise to respiratory problems (Assey, 2009). The requirement of iodine increases during pregnancy because of an increased requirement of T4 in order to maintain a normal metabolism in the mother, transfer of T4 and iodide from the mother to the fetus and to offset the loss of iodide through the kidney due to an increase in the renal clearance. For pregnant women and lactating, median urinary iodine concentrations of 150-249 µg/l indicates adequate iodine intake (WHO, 2007).

To attain this level of urinary iodine concentration, dietary intake of 20-40 ppm is recommended. However, with the current recommended iodation at factory level (40-80 ppm) with contribution of improved market chains and salt handling practices, consumers may likely be exposed to a high risk of iodine toxicity. There is possibility of people to consume more than 5g of salt per person per day. Salt from Kenya which is mostly consumed in Arusha and that salt have resulted in excess intake of iodine in Kenya. People in Arusha consume other food rich in iodine like roasted meat spiced with iodated salt, soup which is popular and bakery foods. These reasons could contribute to excess intake of iodine among individuals. In light of the foregoing, this study was designed to assess iodine status of pregnant and lactating women in Arusha municipality and to determine their iodine intake in order to find out if they exceed the WHO limit of 500 μg/day. The information obtained will be used to advice the Government on appropriate iodine limits to set for salt to avoid excess iodine intake. This study will be useful for food and nutrition policy makers, salt industries and food processors by making policies that will help to reduce iodine levels.

1.4 Objectives

1.4.1 Overall objective

The overall objective of this study was to assess the iodine status of pregnant and lactating women.

1.4.2 Specific objectives

Specific objectives were to:

(i). Determine iodine in salt at household, retail and wholesale levels

(ii). Determine salt handling practices in Arusha which may affect the stability of iodine in salt.

(iii). Assess iodine intake iodine in pregnant and lactating women using urine biomarker.

(iv). Determine the risk of exceeding the daily iodine intake among pregnant and lactating women.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Magnitude of the IDD problems

Iodine deficiency disorders is a major public health problem worldwide in which more than two billion people have insufficient iodine intake including 285million school-age children. Iodine deficiency is estimated to affect more than 1.6 billion people globally and 150 million are in Africa (WHO, 2004). Iodine deficiency is the number one cause of preventable brain damage in children and an important cause of infant deaths. According to UNICEF (1995), 5.7 million people globally are cretin, 300 million people have lowered mental ability, 740 million people have goiter while 2200 million people are at high risk of IDD. Universal salt iodization is the main strategy to eliminate IDD. Globally, more than 100 countries had salt iodations programmes by the year 2000, with nearly 70% of household having access to iodated salt compared with only 20-30% in 1990 (Hetzel, 2005). In Tanzania the problem of iodine deficiency was reported in the early 19^{th} century and efforts to combat it started in 1950s. A country survey conducted in Tanzania in the 1970s showed that, 40% of the population was at risk while 25% equivalent to 5.6 million people) were already suffering from iodine deficiency (WHO, 2004).

2.2 IDD problems

The term Iodine Deficiency Disorders (IDD) refers to all the ill effects of iodine deficiency that are preventable by ensuring that the population has an adequate intake of iodine. The most notable effects are related to brain development of a child and loss of intelligence quotient (IQ). A variety of mechanisms exist to compensate for low levels of iodine intake. These include enlargement of the thyroid gland (goitre). Only when these mechanisms fail do the clinical signs of hypothyroidism (also known as myxoedema) develop. Symptoms and signs of hypothyroidism include lethargy, weakness, weight gain, poor concentration, oedema, myalgia, dry skin, delayed tendon reflexes and slow heart rate. Other effects include hyperthyroidism in elderly, impaired mental function and retarded physical development in children. In pregnancy, iodine deficiency is associated with an increased risk of miscarriage, stillbirth and congenital abnormality. Cretinism is the result of iodine deficiency in the developing foetus, and is characterised by mental retardation, deaf mutism, and spastic diplegia. A less common form of cretinism is the myxoedematous type, which is characterised by hypothyroidism and dwarfism (Hetzel, 2004).

2.3 Physiological Role of Iodine

At present, the only physiological role of iodine in the human body is the synthesis of thyroid hormones by the thyroid gland. Therefore, physiological role of iodine is determined by normal thyroxine (T_4), production by the thyroid gland without stressing the thyroid iodide trapping mechanism or raising thyroid stimulating hormone (TSH) levels. Iodine from the diet is absorbed throughout the gastrointestinal tract. Dietary iodine is converted to iodide ion before it is absorbed. The iodide ion is bio-available and absorbed completely from food and water (WHO/FAO, 1998). Iodine enters the circulation as plasma inorganic iodide, which is cleared from circulation by the thyroid gland and kidneys. The iodide is used by the thyroid gland for synthesis of thyroid hormones, and the kidney excretes iodine through urine. The excretion of iodine in the urine is a good measure of iodine intake. In a normal population with no evidence of clinical iodine deficiency either in the form of endemic goitre or endemic cretinism, urinary iodine excretion reflects the average daily iodine intake. Therefore, for determining the iodine requirements, the important indices are serum $T_{4,}$ $T_{3,}$ TSH levels (indicating normal thyroid status) and urinary iodine excretion (WHO/FAO, 1998).

2.4 Adverse Effects of Excess Iodine Intake

Adverse effect of exposure to excess iodine was reported about fifty years ago. Excess iodine intake causes an inhibition of thyroid iodation. Intake of iodine from a variety of supplements, salt and water may pose a risk of excessive iodine intake in some individuals. Manifestations of excess iodine intake include thyroiditis, hyperthyroidism and sensitivity reaction. Side effect of iodations of salt is rare and usually mild, being associated with rapid increase in iodine intake and state of iodine overload. Specific population groups such as pregnant and lactating women, however, require higher iodine levels than recommended for normal healthy adults. They should have median urinary iodine within the range 200-299 µg/l, which is their normal requirement (Vicent, 2009). Previously published reports have described both sub-clinical and overt thyroid dysfunction as a result of excess iodine ingestion. Goiter, hypothyroidism, and/or a rise in serum TSH values have been reported from ingestion of excess iodine. Individuals with underlying autoimmune thyroid disease, those with a previous history of postpartum thyroiditis or sub-acute thyroiditis, or patients who have undergone partial thyroidectomy have all been shown to be prone to iodine-induced goiter and hypothyroidism. Although the natural history of thyroid dysfunction related to acute excess iodine ingestion has been well characterized, the effects of chronic excess iodine intake remain poorly understood. Acute excess iodine ingestion has long been known to reduce iodine organification, knows as acute Wolff-Chaikoff effect (Delange *et al.,* 2002). The social groups most affected by excessive iodine intake are pregnant and lactating women.

2.4.1 Pregnant women

Iodine requirement during pregnancy is increased to provide for the needs of growing the foetus and to compensate for the increased loss of iodine in the urine due to increased renal clearance of iodine during pregnancy. Iodine plays a critical role in neuropsychological development of the foetus throughout gestation and in the first two years of life. During the first two trimesters of pregnancy the foetus is entirely dependent on the maternal thyroid hormone supply as the foetal thyroid does not develop until 13-15 weeks gestation. As the foetus progresses into the third trimester, it develops the ability to produce its own thyroid hormones but it is still dependent on maternal iodine for hormone synthesis (Zimmerman, 2009). An adequate iodine intake during pregnancy is essential for the synthesis of maternal thyroid hormones and normal brain development in the fetus. If iodine insufficiency leads to inadequate production of thyroid hormones and hypothyroidism during pregnancy, then irreversible fetal brain damage would result. The Technical Consultation Commettee of WHO proposed to increase the current WHO/FAO (2008) recommended daily nutrient intake for iodine during pregnancy from 200 to 250 µg. The committed stated that, a daily intake greater than 500 µg is not necessary as it would not provide any additional benefit for health and theoretically may be associated with impaired thyroid function. As earlier stressed by Anderson *et al.* (2007), it is considered important to monitor the risk of thyroid disease due to an excessive consumption of iodine, as well as due to deficiency. Exposure to excessive iodine intake during pregnancy may lead to transient hypothyroidism in newborn infants. Fetal goiter may also occur and in rare instances can give rise to respiratory problems. An increase in the incidence of thyrotoxicosis may occur after introduction of iodated salt (Vicent, 2009).

2.4.2 Lactating women

During lactation, the physiology of thyroid hormone production and urinary iodine excretion returns to normal, but iodine is concentrated in the mammary gland for excretion in breast milk. Due to the need to ensure that the infant gets enough iodine from breast milk to build reserves in their thyroid gland, it was recommended that lactating women should continue to consume 250 µg/day of iodine. This also represents an increase in the recommended intake of iodine by 50 µg/day compared with earlier Recommended Nutrient Intake of 200 µg/day. Intake for lactating women should `not exceed 500 µg/day (Anderson *et al.*, 2007). A daily intake greater than 500mg day is not necessary as it would not provide any additional benefit for health and theoretically may be associated with impaired thyroid function (WHO, 2007).

Table 1: WHO/UNICEF/ICCIDD criteria for assessing population iodine status using population median urinary iodine concentration (ug/l)

Iodine status	General population)	Pregnant and lactating women
Excessive	≥300	≥500
Above requirement	200-299	250-499
Iodine sufficient	100-199	150-249
Mild iodine deficiency	50-99	50-150
Moderate iodine deficiency	20-49	<20-49
Severe iodine deficiency	<20	<20

Source: WHO/UNICEF/ICCIDD (2007).

2.5 Biomarker of Iodine Status

Most of the excess iodine taken by the body is excreted, making the urinary iodine concentration (UIC) a good marker for recent dietary iodine intake. Median UIC is recommended for defining the population iodine status through a specific group of people, such as pregnant women, lactating women, infants and school-age children. UIC assesses iodine nutrition status at the time of measurement. If a sufficient number of specimens are collected, profiles of iodine concentration in the morning or from other casual urine specimens will provide an adequate assessment of a population's iodine nutrition. Thirty determinations of iodine in urine form a defined sampling cluster. The normal urinary range has been extrapolated by WHO (1997) to include pregnant and lactating women. It reflects their additional needs to avoid risk of iodine deficiency to fetuses and themselves. Intake of >300 μg/l per day has been discouraged, particularly in areas where iodine deficiency has previously existed. Both extremely low and high iodine intakes correlate with an elevated tendency for thyroid autoimmune abnormalities (Delange *et al.*, 2002). Other important indexes are serum T_4 and TSH levels indicating normal thyroid status (FAO, 1998).

2.6 IDD Prevention Programs

Foundation of the International Council for the Control of iodine Deficiency Disorders (ICCIDD) in 1985. Global efforts were initiated in 1990 when IDD was recognised by the World Health Assembly as a problem of public health significance and a resolution was accordingly passed which WHA in 1991 adopted the goal of iodine deficiency elimination in all countries by the year 2000. In 1994 WHO-UNICEF Joint Committee on Health Policy. Endorsement of Universal Salt Iodization as a save, cost-effective, and sustainable strategy to ensure sufficient iodine intake by all individuals by 2005. WHO, United Nations Children's Fund (UNICEF) and the International Council for Control of Iodine Deficiency Disorders (ICCIDD) recommended Universal Salt Iodation (USI) as a safe, cost-effective and sustainablestrategy to ensure sufficient intake of iodine by human and animals (Assey, 2009). Attempts to improve iodine nutrition in areas of iodine deficiency have been made using iodine supplementation through iodination of bread, water, sugar, oil etc. Although these routes of supplementation have been successful in some regions and communities, it appears that salt iodization is the simplest, cheapest and most effective means of providing optimum iodine nutrition.

2.7 Salt Iodation Program

Fortification of salt with iodine is considered the most appropriate measure for a long term solution that will sustainably eliminate iodine deficiency. Duo or triple fortification of salt with essential micronutrients i.e. iodine, iron, vitamin A has already proven effective. Salt iodation is a process of mixing iodine in the form of potassium iodate or potassium iodide with salt powder/crystals. Potassium iodate is less soluble but more stable than iodide and therefore preferred for hot and humid climates. The salt with iodine is referred as ‘iodated salt’if fortified with potassium iodate or ‘iodise salt’ if fortified with potassium iodide. The joint FAO/WHO Expert Committee on Food Additives endorsed the use of potassium iodate and potassium iodide compounds since they had a long-standing and widespread history of use for fortifying salt without apparent adverse health effects (ICCIDD, 1999). Quality of salt suitable for iodation on a dry basis, according to the Codex Alimentarius specifications for a food grade salt, should not be <98% sodium chloride (NaCl) by weight with <3% moisture content and 0.5% insolubles. Dual and triple fortification of salt with major micronutrient in the form of microencapsulation is another advanced method expected to cost less than carrying out separate single fortification programmes (ICCIDD, 1999).

2.8 Stability of Iodine in Salt

One of the main objective of any salt iodization program is to ensure that iodine levels in the salt are maintained at recommended levels up to the time of consumption. The quality of salt, the compound used for fortification, the type of packaging materials and climatic conditions are some of the factors which determine iodine retention in salt as salt is hygroscopic at relative humidity above 76%. Improper handling of iodated salt such as failing to keep it in airtight containers, washing it or not covering the pot during cooking may also add to iodine losses

(WHO/ICCIDD/UNICEF, 1996). Elemental iodine readily sublimes and is rapidly lost to the atmosphere through diffusion. Potassium iodide is less stable than potassium iodate, as it can be oxidized to elemental iodine by oxygen or other oxidizing agents, especially in the presence of impurities, such as metal ions and moisture. Potassium iodate may be reduced to elemental iodine by a variety of reducing agents in the salt, such as ferrous ions. Moisture is naturally present in the salt, or is abstracted from the air by hygroscopic impurities such as magnesium chloride. The pH of the condensed moisture on the salt is very much influenced by the type and quantity of impurities present, and this affects the stability of the iodine compounds. Elevated temperatures increase the rates of iodine loss. The impurities, physical characteristics and the extent of processing at the source have a major effect on the stability of iodine in the salt (Diosady *et al.,* 1997).

Iodine is added to salt in the form of potassium iodide or iodate either as a dry solid or aqueous solution at the point of production. Iodate is typically used in tropical climates, due to its better resistance to oxidation. Availability of iodine from iodized salt at the consumer level can vary widely due to a number of factors, including the variability in the amount of iodine added during production, its uneven distribution within the batches or bags caused by poor mixing, poor handling during transportation, during storage and meal preparation. Moisture plays a critical role in stability of iodine. The rate of iodine loss is strongly influenced by the packaging materials and relative humidity (Diosady *et al.,* 1997). The stability of iodine in salt and levels of iodization are issues of crucial importance to national health authorities and salt producers, as they have implications for programme effectiveness, safety, and cost (Diosady and Venkatesh , 1997). The actual availability of iodine from iodized salt at the consumer level can vary over a wide range as a result of; variability in the amount of iodine added during the iodization process, uneven distribution of iodine in the iodized salt, within batches or individual bags, insufficient mixing of salt after the salt iodization process and/or variation in particle size of salt crystals in a batch or bag, the extent of loss of iodine due to salt impurities, packaging, and environmental conditions during storage and distribution, loss of iodine due to food processing, washing and cooking processes in the household and the availability of non-iodized salt from unconventional marketing sources (Diosady and Venkatesh , 1997). In Tanzania availability of iodated salt at household increased from nearly zero in 1980s to 84% in 2004 (TFNC, 2006).

2.9 Factors Affecting Iodine Stability

One of the main objectives of any salt iodization program is to ensure that iodine levels in the salt are maintained at recommended levels up to the time of consumption. The quality of salt, the compound used for fortification, the type of packaging materials and the climatic conditions are some of the factors which determine iodine retention in salt, considering that salt is hygroscopic at a relative humidity above 76% (Diosady *et al.*, 1997). When iodated salt is improperly packed and transported over long distances under humid conditions, it will absorb moisture and becomes wet, dissolving and carrying the iodate to the bottom of the bags, and finally it can be lost if such bags are porous to water. Salt packed in such materials may lose as much as 75% of its iodine content over nine months (Diosady *et al.*, 1997).

High density polyethylene bags and polyethylene laminated bags are recommended for bulk packaging purposes. When jute/sisal bags are used, they should have inner linings of low density polyethylene sheet. For high-income countries, air-tight containers are used for salt packaging, and the quality of the salt remains higher compared to raw salt used in many low-income countries. Exposure to heat or sunlight can increase iodine loss by sublimation. Other iodine losses also occur from improper handling of iodated salt, such as failing to keep it in air-tight containers, washing it or not covering pots during cooking (Diosady *et al.,* 1997). Control of moisture content in iodized salt throughout the manufacturing and distribution by improved processing, better packaging and storage is critical to the stability of the added iodine.

2.8 Specification for Iodine Content in Salt

In order to iodise salt, per capita salt consumption in an area should first be taken into account to determine the concentration of iodine required to meet the daily iodine requirement. If salt consumption is high, the iodine level should be reduced and vice-versa for low salt intake areas. Previously, accepted levels of salt consumption were in the range 10-15 g per day, but now this amount is regarded as excessive because of the increased risk of hypertension. For this reason, salt levels in the range of 3-6 g per day are now recommended. The salt iodation regulations were instituted in 1994 but implementation only started in January 1995. Iodation at factory level was set at 75–100 parts per million. According to the sa,e regulations iodation level in salt at retail outlets was set at 37.5 ppm. Due to improved storage, packaging and ditribution practices in Tanzania, the Government reviewed the regulations in 2010 thus reducing iodation level at factory to 40-80ppm and at retail level to 20-70 ppm (TFDA, 2010). The recommended iodation levels for Tanzania is slightly higher than those recommended by WHO 20-40 ppm because of losses during salt handling/storage and utilization which can be above 50% at some areas (WHO, 2007).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

Arusha urban is one of the five districts of Arusha region. It is bordered to the South by Monduli district and to the North, East and West by Arumeru district. Arusha urban is situated on the slopes of Mt. Meru (5000 m above sea level). It is located between latitude 3^0 16 ' S and 3^0 20 ' S and longitude 36^0 37 ' E and 36^0 50 ' E. Average temperatures range from 16º C in the upland area to 26º C in the lowlands. Rainfall ranges from 250 mm to 1200 mm per annum. The town is situated 653 km East of Dar es Salaam.

According to 2002 census, Arusha urban has a population of 282 712 people out of whom 49% are males and 51% are females. Arusha urban has a population density of 3040 people per km^2, family size of 4 and dependant ratio of 59%. The current population projection is estimated at 359 044 people. The indigenous inhabitants of Arusha are Waarusha and Maasai. The Arusha Municipality has three administrative divisions namely, Themi, Elerai and Suye. These are further divided into seventeen wards namely, Kati, Sekei, Themi, Kaloleni, Levolosi, Ngarenaro, Unga Limited, Daraja Mbili, Baraa, Sokoni, Elerai, Kimandolu, Oloirien, Sombetini, Terrat, Engutoto and Lemara. Arusha urban has 42 dispensaries. The district also has fifteen health centres of which 10 are private and 5 are public and five hospitals of which 4 are private and one is public. The economic activities in Arusha district include agriculture, agroprocessing industry, livestock, minerals and tourism.

3.2 Study Design

The study is a cross-sectional design in which data were collected only once. A cross sectional study is simple, inexpensive in terms of time and resources, flexible, minimizes bias and maximizes reliability of data (Bailey, 1998).

3.3 Sampling Frame

This study involved all pregnant and lactating women residing in Arusha urban district who were receiving prenatal and postnatal care at Themi and Ngarenaro Reproductive and Child Care health clinics. The study also involved businessmen and women selling salt at wholesale and /or at retail levels. The study was conducted in 13 wards out of 17 wards of Arusha municipality from which a representative sample was randomly selected for those women who were receiving the service at RCH . Two RCH clinics namely, Themi and Ngarenaro located in the selected ward were involved in the study. Respondents were randomly selected among pregnant and lactating women receiving services at the Reproductive and Child Care health clinics. A total of 50 wholesale and retail shops were also selected randomly from the study wards. The study excluded lactating and pregnant women who declined to participate, women with known chronic conditions e.g. diabetic women, and those with HIV/AIDS.

3.4 Sampling Techniques

The present study involved the selection of participants randomly to obtain representative sample of pregnant and lactating women. Random sampling techniques were also used to get wards, clinics, wholesale and retail shops. All pregnant and lactating women residing in the selected wards and receiving services in the selected Reproductive and Child Care health clinics were selected for the study except that a cluster sampling was used in the household with more than one eligible mother. The number of mothers drawn into the sample was restricted to two for each category which were pregnant and lactating only. A household was defined as a group of people (usually family members) living under one roof and sharing the same pot.

3.5 Sample Size

Sample size was determined according to the WHO (1991), ICCIDD/UNICEF/PAMM (2000), and ICCIDD (1999) recommendations for statistical power analysis. As recommended by ICCIDD (1999) and ICCIDD/UNICEF/PAMM (2000), a multistage stratified (cluster) sampling technique was used to obtain the sample size. The size of the sample was calculated from the relationship:

$n=Z^2. (1- p). D_{eff}/d^2.p$

Where n= sample size, Z= 1.96 for confidence interval limit of 95%, p=expected prevalence of IDD, $D_{eff=}$ sampling (multistage cluster) effect ($2 \leq D_{eff} \geq 4$), and d=relative precision.

A relative precision of 30% and a cluster/strata effect of 3 are recommended by ICCIDD (1999) for surveys involving evaluation of prevalence of IDD. Applying the above formula and using an expected prevalence of total goiter rate of 23%

(ICCIDD, 2001a) a cluster effect of 3 and relative precision of 30%, a sample size of 429 households was used for this study.

3.6 Data Collection

Primary data were collected by trained enumarators using a structured and pretested questionnaires:

3.6.1 Construction of questionnaires

Two questionnaires were constructed for the study. The first questionnaire was designed for the pregnant and lactating women. The questionnaire was divided into three sections. Section one solicited information about maternal age, marital status, education level, parity, family size and occupation. Section two covered information about mother's knowledge and altitude about dietary iodine, iodine deficiency disorder, the use of iodated salt, salt handling and storage practices and iodine status of the mother. Section three solicited information about cooking practices that could affect iodine stability. The second questionnaire was designed for the traders and solicited information about their knowledge, attitudes and practices regarding selecting, buying, handling and storing iodized salt.

3.6.2 Pre-testing the questionnaire

The questionnaire for pregnant and lactating women was pre-tested in a sample of 10 mothers selected from Morogoro urban district, while that for wholesale and retail traders was pre-tested in a sample of 20 traders selected in Morogoro municipality.

Adjustments were made to the questionnaire prior to the administration in the study area.

3.6.3 Training of enumerators

Two nutritionist enumerators received intensive training on how to conduct the interviews and the interpretation of questions in the questionnaires.

3.6.4 Administration of the questionnaires

Administration of the questionnaire was done at the health clinics namely Themi and Ngarenaro. The interview was conducted face- to face with the respondents. At first, the researcher explained the purpose of the study to the respondents and then asked if they were willing to participate. If the respondent agreed, she was then interviewed, and then signed the consent form. Visits were also paid to the wholesale and retail shops where by face to face interviews were conducted.

3.7 Collection of Urine and Salt Samples

Salt and urine samples were collected from the respondents the next day after the interview. Respondents were given plastic sample bags (polyethylene) to put salt that they were using at their households. The salt samples were packaged in a moisture proof, airtight polyethylene sample bags. A sample of urine was collected from all pregnant and lactating women at the day of interview. Each respondent was given a marked sterile sample bottle in which she put her urine sample. Both salt and urine samples were properly packaged in airtight containers and transported to the

Laboratories of the Muhimbili National Hospital, Dar es Salaam for iodine determination.

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3.8 Analysis of iodine in salt

Iodine concentration in salt samples was determined by iodometric titration involving digestion of iodized salt with sulphuric acid in presence of excess potassium iodide to liberate free iodine. The free iodine was quantified by titration with sodium thiosulphate, using starch as an indicator (WHO, 2001). Ten grams of salt were measured into a 250 ml stoppered conical flask. Fifty ml of double distilled water was measured into the conical flask to dissolve the salt. The flask was shaken carefully till all the salt dissolved. One ml of 2N H_2SO_4 was added followed by 1ml of 10% KI solution. The flask was kept in the dark (closed cupboard) for 10 minutes. The flask was removed and titrated against 0.0005N Na S_2O_3. During titration, the yellow color changed to pale. Two drops of starch solution were added as an indicator. The titration was continued until the solution become colourless. The titre was then recorded. Calculation for the iodine concentration in salt was done and expressed in parts per million (ppm).

Iodine concentration in the salt sample was calculated from the relationship:

1) 1ml of 0.005N $Na_2S_2O_3$ = 0.1058 mg of iodine ml
2) Thus, titration volume X 0.1058 = iodine concentration (ppm) in 10gm of salt

3.9 Analysis of Iodine in Urine

Iodine concentration in urine sample was determined by the method of ICCIDD/UNICEF/WHO (1993) as revised by WHO (2007). The urine sample was thoroughly mixed to get a homogenous mixture. Two hundred and fifty µl of urine were drawn into 13 x 100 mm test tubes. Duplicate iodine standards and a set of internal urine controls were included in the batch. One ml of ammonium persulfate was added into each test tube. The test tubes were heated for 45 – 60 minutes at 91-95 °C on a using heating block. The test tubes were there after cooled to room temperature. About 3.5 ml of arsenious acid solution was added and mixed by vortex and allowed to stand for 15 minutes. Four hundred µl of ceric ammonium sulfate solution were added to each test tube at 15 to 30-second intervals between successive tubes and mixed well after addition. A stopwatch was used for this process. Test tubes were allowed to stay at room temperature for exactly 30 minutes after the addition of ceric ammonium sulfate to the first tube. The absorbance was read at 405 nm at the serial interval of 15 seconds following the order of addition of ceric ammonium sulfate. A standard curve of iodine concentration on the abscissa against its optical density at 405 nm (OD405) on the ordinate was constructed. Iodine concentration in µg/l for each specimen was calculated by using linear regression equation obtained from the best fit line (WHO, 2007).

3.10 Analysis of Moisture Content in Salt

The moisture content in the salt samples was determined by using AOAC drying method (AOAC, 1995). One gram of salt was weighed into pre-dried and pre-weighed petri-dishes. The total weight of dish and sample was recorded. Then the petri-dish with the salt sample was placed in an oven pre-set at 105°C and allowed to dry for four hours. The dish was removed and placed in a desiccator to cool. The weight of the dish with the sample was taken when the dishes cooled to room temperature. The dish was placed back into the oven and left to dry until the weight stabilized. The moisture content was calculated for the relationship:

$$\text{Moisture} = \frac{\text{Wt of dish sample- [Wt of dish + dry sample]} \times 100}{\text{Wt of sample taken}}$$

3.11 Data Analysis

Information from the questionnaires was coded and analyzed using the statistical package for social sciences (SPSS) computer software version 12.0. Descriptive analysis was used to determine frequencies, percentages and means of various variables such as demographic information, cooking practices, knowledge and attitudes. Chi-square test was used to study relationships between iodine in salt and urinary iodine concentration (UIC).

3.12 Ethical Issues

Approval was obtained from the national ethics committee before starting the study. Permission was obtained from Arusha Region Health Authorities to conduct the study in the selected RCH clinics. Consent of participant was obtained after they were given the information about the study. They signed consent forms to affirm their willingness to participate in the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSION

4.1 Socio-Economic and Demographic Characteristics of the Respondents

Table 2 shows the socio-economic and demographic characteristics of the respondents. Majority of women are young as they fall in the range of 20-30 years old. About 35.3% (95% CI; 24.3%, 45.0%) of pregnant women were at the age of 25-30 years while 37.0% (95% CI; 26.1%, 47.0%) of lactating women had age in the range 20-25years. Only 10.6% (95% CI; 4.1%, 23.1%) and 19.9 % (95% CI; 12.4%, 20.6%) of the pregnant and lactating women, respectively, were at the age of 15-20 years. About 19.7% (95% CI; 18.9%, 20.4%) of pregnant women and 20.4% (95% CI; 52.7%, 93.5%) of lactating women, respectively, were above 30 years old. There was no significant difference in age distribution among pregnant and lactating women ($p>0.05$). Marital status showed that, 86.2% (95% CI, 61.1%, 87.6%) and 75.4% (95% CI; 70.3%, 80.4%) of pregnant and lactating women, respectively, were married, while 13.8% (95% CI, 1.4%, 26.1%) and 23.7% (95% CI, 11.9%, 35.0%) of the pregnant and lactating women, respectively, were single.

Majority of women had attained primary school education with 69.3% (95% CI; and 65.9% (95% CI; 60.7%, 71.0%) of pregnant and lactating women, respectively, having attained primary school education. Only 24.8% (95% CI; 18.8%, 30.6%) and 27.5% (95% CI; 2.7%, 34.2%) of the pregnant and lactating women, respectively, had attained secondary school education. Few of the lactating women had attained college education (0.9%), while also 3.7% and 2.4% of pregnant and lactating women, respectively, had attained vocational education. There were significant variations in educational level ($p<0.05$) among the pregnant and lactating women. Majority of the respondents had attained only primary education. Formal education is essential, not only in understanding nutrition information but also in opening up chances for employment and other entrepreneurial skills. Low level of education contribute to their variation in iodine status mainly in cooking methods, average time while cooking and adding salt to food as majority were adding salt to food initially while cooking.

Regarding occupation, 44.5% (95% CI; 34.6%, 54.3%) and 38.9 % (95% CI; 34.7%, 43.0%) of the pregnant and lactating women, respectively, were self employed, 18.8% (95% CI; 6.0%, 30.7%) and 25.6% (95% CI;1.3%, 37.2%) were housewives, 20.2% (95% CI; 8.0%, 32.0% and 21.3% (95% CI; 9.0%, 33.2%) of pregnant and lactating women, respectively, were employed for wage, 7.3 % and 9.5 % of the women were casual laborers, while 9.2% and 4.7% of the pregnant and lactating women, respectively, were farmers.

Majority of the women (97.6% (95% CI; 77.4%, 99.6%) of pregnant and 79.3% (95% CI; 73.8%, 84.7%) of lactating women) had a parity of 1- 4 births. Family size ranged between 2-5 individuals per household. The high maternal parity was reflected in the family size of 2-5 people. The findings were in agreement with the data reported in National 2002 Population and Housing Census, in which the average family size in Arusha district was four (URT, 2003).

Table 2: Socio-economic and demographic characteristics of respondents

	Pregnant (n=218)		Lactating (n=211)			
Parameters	**n**	**%**	**n**	**%**	**$\chi2$**	**P-value**
Age of the mother						
15-20	23	10.6	42	19.9	6.225	4.58
20-25	75	34.4	78	37		
25-30	77	35.3	48	22.7		
Above 30	43	19.7	43	20.4		
Total	**218**	**100**	**211**	**100**		
Marital status						
Married	188	86.2	159	75.4	3.036	0.28
Single	30	13.8	50	23.7		
Divorced	0	0	2	0.9		
Total	**218**	**100**	**211**	**100**		
Education level					7.587	0.05
None	5	2.3	7	3.3		
Primary school	151	69.3	139	65.9		
Secondary school	54	24.8	58	27.5		
College/university	0	0	2	0.9		
Training	8	3.7	5	2.4		
Total	**218**	**100**	**211**	**100**		
Occupation						
Farmer	20	9.2	10	4.7	17.499	0.06
Self employed	97	44.5	82	38.9		
Paid employed	44	20.2	45	21.3		
Casual	16	7.3	20	9.5		
Housewife	41	18.8	54	25.6		
Total	**218**	**100**	**211**	**100**		

4.2 Iodine Content in Salt

Table 3 , shows iodine concentration in salt samples collected at household level. It was revealed that, 46.7% (95% CI; 39.7%, 53.6%) contain iodine in the range of 16-39 ppm , while 32.9% (95% CI; 25.0%, 40.6%) of the salt sample had iodine concentration in the range 10-15 ppm. Likewise, 19.9% (95% CI; 11.4%, 28.3%) of salt sample had iodine concentration in the range 40-80 ppm, and only 0.5% of salt samples had iodine concentration below10ppm. While none of the salt samples had iodine concentration more that 80 ppm which is the upper cut of iodation in Tanzania's standard (TFDA, 2010). According to the Tanzania Food Drug and Cosmetics (Salt Iodation) regulations, 2010, iodine concentration in salt at retail level should not be less than 25 μg/g at the household level (TFDA, 2010). Tanzania had its maximum iodine levels reduced from 100 ppm in the 1990s (URT, 1994), to 80 ppm) in 2010 (TFDA, 2010). The recommended iodation levels for Tanzania are slightly higher than those recommended by WHO (2007) to compensates losses during salt handling/storage and utilization which can be as high as 50% (WHO, 2007). In response to survey data showing relatively high iodine levels in salt, Kenya has enacted new regulation which reduced the level of iodine from 168.5ppm to between 50 and 84 ppm (ICCIDD, 2007).

The quality of salt, the compound used for fortification, the type of packaging materials and climatic conditions are some of the factors which determine iodine retention in salt as salt is hygroscopic at relative humidity above 76%. Improper handling of iodated salt such as failing to keep it in airtight containers, washing it or not covering the pot during cooking may also add to iodine losses (WHO/ICCIDD/UNICEF, 1996). Due to improvement in technology, infrastructure and transportation, the market chains have become faster and more efficient. Therefore, salt reaches the consumer with very high iodine content, ranging from 40-80 ppm. Apart from locally produced salt, Tanzania is also consuming salt originating from other countries including Kenya. Processing, packaging and better handling of salt along the market chains have also improved, which contribute to high retention of iodine in salt by the time it reaches the consumer. Consequently, making consumers iodine concentration in salt to remain above the 20-40 ppm recommended by (WHO, 2007). The study done by Assey *et al*. (1999) revealed that, although a high proportion of these samples had iodine contents below the national recommended level, 17% of them were within the WHO recommendation of 20-40 ppm, and therefore contained enough iodine to contribute to the reduction of iodine deficiency. Moreover, 4.8% of the salt samples were over-iodinated and 30% were extremely under-iodinated, raising awareness of the possibility of inadequate quality control during the salt iodation or potential losses due to poor salt handling.

Table 3: Iodine concentration in salt samples at household level

Iodine content (ppm)	N	%
<10	2	0.5
10-15	141	32.9
16-39	200	46.7
40- 80	85	19.9
Total	**428**	**100**

4.3 Factors that Affect Iodine Stability During Storage and Handling

Figure 2 indicates the storage and handling practices that were used by the respondents. About 70.6 % (95% CI; 63.0%, 77.7%) and 81.5% (95% CI; 75.6%, 87.3%) of pregnant and lactating women, respectively, reported to use plastic containers to store their salt at the household, 19.7% and 15.2% of pregnant and lactating women, respectively, stored their salt in transparent glass bottles, while few (6.4%) used tin containers and plastic packets (6.5%). Iodized salt must be stored in closed airtight containers and stored in cool, dark and dry place. High density polyethylene bags and polyethylene laminated bags are recommended for salt packaging because they improve stability of iodine. In most developing countries, salt is sold packaged in bulk. Packaging materials include paper, high and low density polyethylene and woven bags made of jute, straw or high density polyethylene are to be used for handling salt. The quality of salt, the compound used for fortification, the type of packaging materials and the climatic conditions are some of the factors which determine iodine retention in salt (Diosady and Venkatesh, 1997).

A study done by Diosady *et al*. (1997) showed that, moisture plays a critical role in the stability of iodine. In particular, when salt is stored at a temperature characteristic of storage and distribution conditions in many developing countries, moisture absorbed by hygroscopic impurities is the major contributor to the rapid loss of iodine. Salt purification is the best technical means of preventing iodine loss; however, this would be prohibitively expensive in the short term for many developing countries. By packaging salt in an effective moisture barrier such as solid low-density polyethylene bags, iodine losses can be significantly reduced . In order to make allowances for the probable losses of iodine, countries must determine iodine losses from local iodized salt under local conditions, as these will be greatly affected by salt source, quality and processing technology.

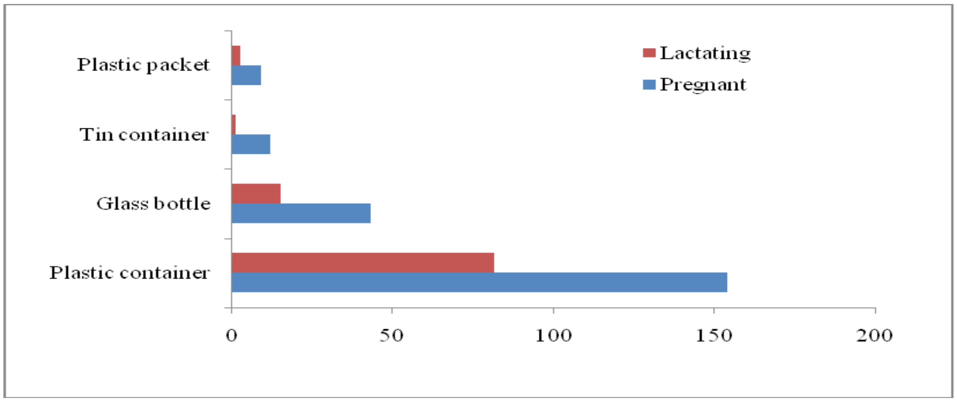

Figure 1: Salt storage and handling practices

4.4 Factors That Affect Iodine Intake

4.4.1 Knowledge about dietary Iodine

Table 4 summarizes the knowledge of the respondents regarding dietary iodine. About 80.5% (95% CI; 14.6%, 86.4%) of pregnant women, have heard about iodated salt while 19.7 % (95% CI; 7.0%, 31.5%) of them had never heard about it. On the other hand, 61.6% (95% CI; 51.0%, 72.1%) of the lactating women have heard about iodated salt and only 38.4% (95% CI; 32.4%, 44.3%) never heard about it. There was significance variation ($p<0.05$) in awareness of iodated salt among the pregnant and lactating women. Knowledge seems to be high among respondents because of public iodine awareness programs which were done by TFNC (TFNC, 2006). Main source of information was shops/market (60.5% (95% CI; 51.0%, 69.0%) and 70.8% (95% CI; 64.3%, 77.2%) of pregnant and lactating women, respectively), media (12.4 % and 3.7% of pregnant and lactating women, respectively), hospital/clinic (7.5% and 9.9 % of pregnant and lactating women, respectively), while few got the information from schools (10.1% and 4.4%) of pregnant and lactating women, respectively). There was significance variation in different source of information ($p<0.05$) among pregnant and lactating women. The study showed that, the shopkeeper and traders knew about iodated salt, and they passed the information to their consumers.

About 89.9% (95% CI; 85.6%, 94%) of pregnant women could not identify iodated salt by reading the labels, but 9.9 % said could identify the iodated salt by reading the labels. Meanwhile 82.9% (95% CI; 27.0%, 88.4%) of lactating women could not identify the iodated salt by reading the labels, while 16.1% could identify iodated salt through the labels. Only 9.9% and 15.2% of pregnant and lactating women, respectively, could identify the iodated salt by reading the labels. There is significance variation in identification of iodated salt among pregnant and lactating women, ($p<0.05$). Majority (90.1% (95% CI; 85.9%, 94.2%) and 84.8% (95% CI; 79.5%, 90.0%) of pregnant and lactating women, respectively, could not pick this information from the salt labels. Majority of women could not identify salt if it is iodated because of their low level of education, only those with high knowledge were able to identify by labels. All the respondents used salt while cooking. About 50.5% (95% CI; 41.0%, 59.8%) and 56.9% (95% CI; 48.5%, 65.0%) of pregnant and lactating women, respectively, obtained their salt at nearby shops while 49.5% (95% CI; 40.0%, 58.9%) and 43.1% (95% CI; 32.0%, 53.0%) of pregnant and lactating women, respectively, obtained salt at the local market. There was significance variation in different places they obtain salt ($p<0.05$) among pregnant and lactating women. Majority of the women (84.9% (95% CI; 79.7%, 90.0%) and 74.8% (95% CI; 68.0%, 81.5%) of pregnant and lactating women, respectively, were not sure of what kind of salt they used in past three months, only few of them (15.1% (95%CI; 2.0%, 27.3%) and 25.2% (95% CI; 13.5%, 36.8%) of pregnant and lactating women, respectively, were certain that they used iodated salt. The number of pregnant and lactating women who could not understand whether or not they were using iodated salt in the past three months was significantly higher ($p<0.05$) than those who knew they were using iodated salt.

About 25.7% (95% CI; 19.8%, 31.5%) and 14.2% (95% CI; 2.0%, 21.3%) of pregnant and lactating women, respectively, bought salt measured in cups while 74.3% (95% CI; 67.5%, 81.0%) and 85.8% (95% CI; 85.8%, 90.8% of pregnant and lactating women respectively bought their salt in packets. Majority of the women (99.1% and 98.1%) of pregnant and lactating women, respectively), preferred fine salt while only few of them (0.9 % and 1.9 % of pregnant and lactating women, respectively), preferred coarse salt. Majority of the women ($p<0.05$) preferred fine salt. Coarse salt is not fine, it is not dissolve in food easily, not clear thus made the pregnant and lactating women to prefer fine salt over coarse salt. A study done by Assey *et al.* (2009) showed that, 58 (55%) out of 106 districts, over 90% of the households used iodated salt, while 48 districts (45%) had <90% coverage in the use of iodated salt, including 14 districts found with less than a 50% use of iodated salt. This study demonstrated a marked improvement in iodine nutrition in Tanzania after twelve years after initiation of USI.

Table 4: Knowledge about diatary iodine

	Pregnant (n=218)		Lactating (n=211)			
Parameters	**n**	**%**	**n**	**%**	**χ2**	**P-value**
Heard iodated salt						
Yes	43	80.5	81	61.6	16.51	0.03
No	175	19.7	130	38.4		
Total	**218**	**100**	**211**	**100**		
Source of information						
School	3	1.4	5	2.4	56.538	0.02
Clinic/hospital	15	6.9	20	9.5		
Media	9	4.1	22	10.4		
School and media	10	4.6	9	4.3		
School/media/clinic	1	0.5	11	5.2		
Shops/market	33	15	15	38.9		
Total	**218**	**100**	**211**	**100**		
Identify iodated salt						
Yes	21	9.6	34	16.1	9.811	0.01
No	196	89.9	175	82.9		
Not sure	1	0.5	2	0.9		
Total	**218**	**100**	**211**	**100**		
How can you identify iodated salt						
Reading on packet/label	21	9.9	32	15.2	4.321	0.15
I don’t know	197	90.1	179	84.8		
Total	**218**	**100**	**211**	**100**		
Place to obtain salt						
Shop	110	50.5	120	56.9	5.672	0.01
Local market	108	49.5	91	43.1		
Total	**218**	**100**	**211**	**100**		
Type of salt used						
Iodated	33	15.1	53	25.2	8.33	0.021
Non iodated	0	0	0	0		
Not sure	185	84.9	157	74.8		
Total	**218**	**100**	**211**	**100**		
Form of package						
Cup	56	25.7	30	14.2	6.086	7.39
Packets	162	74.3	181	85.8		
Total	**218**	**100**	**211**	**100**		
Preference						
Course	2	0.9	4	1.9	0	0.000
Fine	216	99.1	207	98.1		
Total	**218**	**100**	**211**	**100**		

A study done at Iringa district by (Mosha *et al.,* 2004) revealed that, most of respondents (92%, n=496) had correct understanding that iodine is essential for protecting the body against goiter while 89.1% of respondent knew that iodine deficiency causes goiter. It was also reported that, respondents got source of knowledge about iodine and iodine deficiency disorders from public health meeting and campaigns, mother and child health clinics, mass media (national radio and TV and primary school. The government used a combination of mass media and community-based nutrition education programs in its advocacy against iodine deficiency disorders (Mosha *et al.,* 2004). Due to government efforts through public awareness on IDD problems, its prevention and control measures, people were able to understand more about iodine and IDD, and the problem has decreased especially on goiter prevalence. Total goiter prevalence had decreased from 25% in 1980s to 7% in 2004. In 27 goiter endemic district, the problem had decreased form an average of 60.7% in 1980s to 12.3% in 2004 (TFNC, 2006).

4.4.2 Knowledge about Iodine Deficiency Disorders (IDD)

Figure 3 shows awareness of iodine deficiency disorders. About 89.4% (95% CI; 85.0%, 93.6%) of pregnant mothers reported to be aware of IDD, while only 10.6% were not aware of IDD. Likewise, 80.1% (95% CI; 74.0%, 85.9%) of lactating women reported to be aware of IDD, while only 19.4% were not aware of IDD. A study done in Iringa showed similar findings as (92.9%, n=496) of respondents in the surveyed household had a clear knowledge of iodine deficiency disorders (Mosha *et al*., 2004). The results of a survey done by Dragana *et al.* (2006) showed that, close to half of the participants (49.1%, n=390) knew IDD. The difference between this study and that of Dragana *et al.* (2006) is that, majority of the respondents had knowledge about IDD while that of Dragana *et al.* (2006) only half of respondents had knowledge about IDDDifferences in knowledge between the target groups exist and are found to be statistically significant.

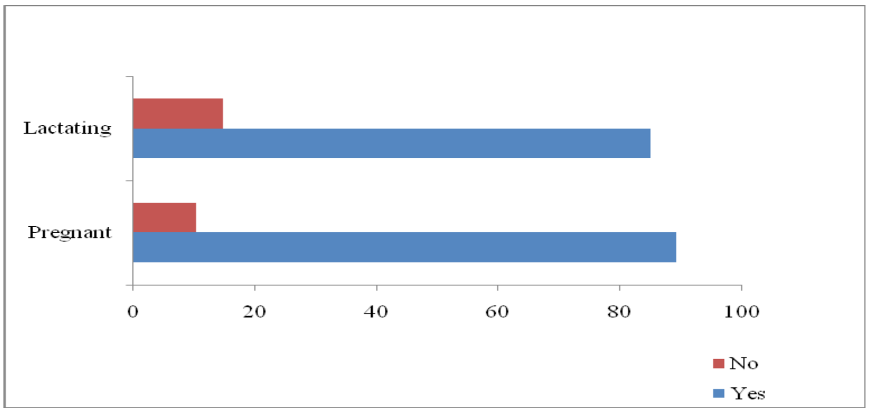

Figure 2: Knowledge about IDD

4.4.3 Knowledge about symptoms of IDD

Table 5 shows knowledge about symptoms of IDD. Majority of women were able to mention correctly the symptoms of iodine deficiency disorders (IDD). About 64.7% (95% CI; 64.7%, 72.8%) of pregnant women and 58.9% (95% CI; 54.0%, 63.0%) of lactating women, respectively, were able to mention goiter. Likewise, 11.4% of pregnant women and 9.9% of lactating women, respectively, were able to mention mental retardation, few of pregnant women (0.3%) and (3.4%) of lactating women, mentioned abortion and stillbirth. About 11.2% of pregnant women and 13.4% of lactating women, respectively, were able to mention goiter and mental retardation. Few of pregnant women (4.7%) and (3.4%) of lactating women were able to mention tiredness. Likewise, 3.1% of both pregnant and lactating women were able to mentioned brain damage. Only 4.6% and 7.0% of pregnant and lactating women respectively, were able to mention growth retardation. High knowledge of IDD among the respondent could contribute to better iodine status. A study by Jooste *et al.* (2004) in South Africa indicated that, only 15.4% (n=2164) of respondents correctly identified iodised salt as the primary dietary source of iodine, 16.2% knew the thyroid gland needs iodine for its functioning, and a mere 3.9% considered brain damage, and 0.8% considered cretinism, as the most important health consequence of iodine deficiency. Respondents from high socio-economic households were considerably less informed about aspects of iodine nutrition than their counterparts from low socio-economic households.

Table 5: Knowledge about symptoms of IDD

	Pregnant (n=218)		**Lactating(n=211)**	
Symptoms of IDD	**n**	**%**	**n**	**%**
Goitre	132	64.7	128	58.9
Mental retardation	24	11.4	21	9.9
Tiredness	11	4.7	5	3.4
Abortion and still birth	4	0.3	7	3.4
Goitre and mental retardation	23	11.2	26	13.4
Growth retardation	14	4.6	15	7.9
Brain damage	10	3.1	9	3.1
Total	**218**	**100.0**	**211**	**100.0**

4.4.5 Reasons for preferring fine salt

Figure 4 shows some of the reasons advanced by the respondents for preferring fine salt. About 23.0% of pregnant women and 34.0% of lactating women, preferred fine salt because it dissolves easily, while 23.0% of pregnant women and 24.5% of lactating women preferred fine salt because it has a good texture. About 15% of pregnant and 14.8 % of lactating women, preferred fine salt because it is readily available, while 12.4 % of pregnant and 2.3 % of lactating women, preferred fine salt because they are used to it. Only 8.2% of pregnant and 10% of lactating women, preferred fine salt because it is white and clear, while few of pregnant women (8.4%) and lactating women (9.5%), respectively, preferred fine salt because of its texture. Observation from this study indicated that, the respondents used fine salt packed in either polyethylene packets or in cups.

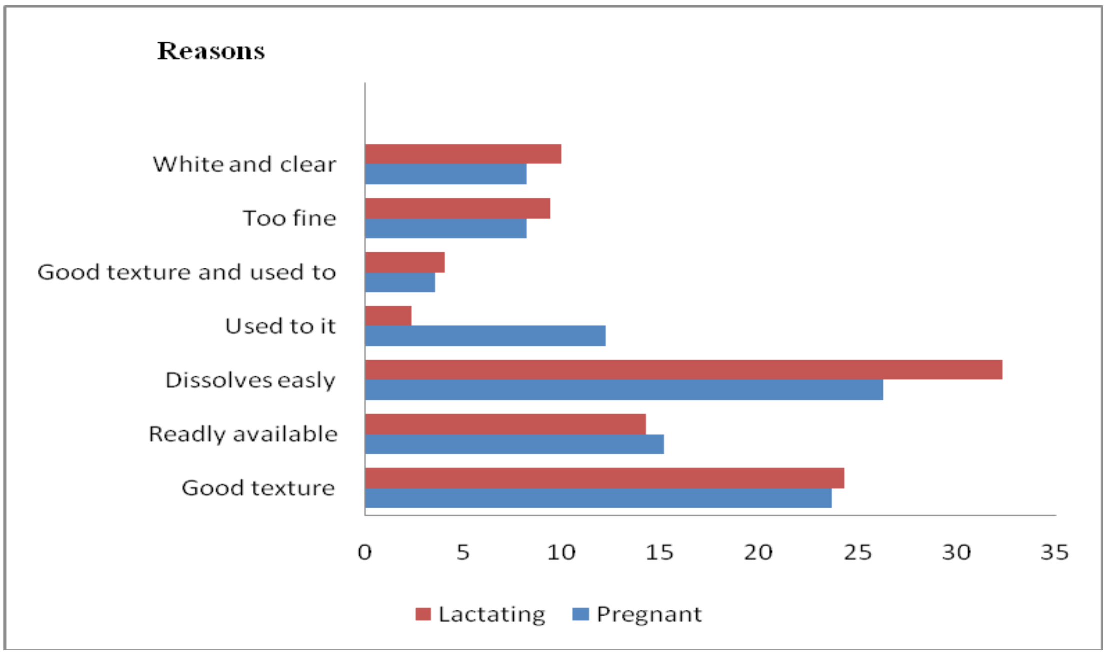

Figure 3: Reasons for preferring fine salt

4.4.6 Factors that affect the choice of salt during purchasing

Table 6 summarizes the factors affecting the choice of salt during buying. About 41.7% and 48.8% of pregnant and lactating women, respectively, had a choice of fine salt while 33.5% and 28.0% of pregnant and lactating women, respectively, had a choice of brand and availability. Few (0.9 % for both groups) made their selection by looking at the price, while 16.5% and 16.1% of the pregnant and lactating women, respectively, selected the salt basing on availability in the market. There was no significance difference concerning factors that affecting choice of salt during purchasing among pregnant and lactating women (p<0.05). A study done by Mosha *et al.* (2004) reported that, most of salt in household was sold in packets only few was sold without packaging in proper air/moisture proof eg., using cups or glass measures. Ninety one percent of the salt had fine texture.

Table 6: Factors affecting choice of salt during purchase

	Pregnant (n=218)		**Lactating (n=211)**			
Factor affecting choice of salt during purchase	**n**	**%**	**n**	**%**	**χ2**	**Pvalue**
Price	2	0.9	4	2.3	17.946	0.01
Availability	36	16.5	17	15.2		
Fine texture	91	41.7	103	48.8		
Fine texture and Availability	73	33.5	62	28		
Fine texture and location	8	3.7	16	4.8		
Price and Availability	8	3.7	9	0.9		
Total	**218**	**100**	**211**	**100**		

4.5 Cooking Practices that Affect Iodine Intake

Some socio-cultural aspects such as cooking practices, consumption patterns, and food habits have been reported to affect the amount of iodine taken by individuals in a household (Tiisekwa and Ngwenya, 1996). Table 6 shows the most common cooking practices. About 35.3% (95% CI; 24.6%, 45.9%) and 41.7% (95% CI; 31%, 52.0%) of pregnant and lactating women respectively cooked their foods by boiling and frying while 23.4% and 17.1% of pregnant and lactating women respectively cooked by boiling only. It was also reported that, 22.5% and 24.2% of pregnant and lactating women respectively cooked by boiling and roasting while 9.6% and 11.4% of pregnant and lactating women fried their foods. Only a few of the mothers (9.2% of pregnant women and 5.2% of lactating women) cooked their foods by roasting. There was no significance difference in cooking methods used among pregnant and lactating women ($p<0.05$). Under normal cooking circumstances, about 20% of iodine is lost during cooking before the food is consumed (WHO/UNICEF/ICCIDD, 1996).

Wang *et al.* (1999) showed losses of 2–63% in iodine content during cooking, depending on the cooking methods and types of foods used. Cooking methods may deplete dietary iodine intake further. Boiling has been estimated to reduce iodine content in food eg. boiling fish reduced iodine content by 50%, and approximately one–fifth was lost by frying or grilling. On this basis, iodine loss from frying and grilling foods would also reduce dietary intake (Cuthbertson *et al.*, 2000). A study conducted by (Verma and Raghuvansh, 2001) revealed, a loss of iodine of about 70% through cooking in cooked diet samples. High losses of iodine while cooking can be attributed to the volatile nature of the compound. To prevent losses while cooking, it is advisable to sprinkle salt on food after cooking rather than adding salt while cooking as has it was been done traditionally. Further, storage of salt in hot and humid conditions near the cooking area may also lead to iodine loss. Cooking practices such as boiling, steaming, roasting enhance iodine degradation.

The study revealed that, majority of the women added salt to the food at the beginning (43.1% (95% CI; 32.0%, 53.0%) and 45.5% (95% CI; 24.6%, 45.9%) of pregnant and lactating women, respectively), while 37.6% and 30.8% of pregnant and lactating women, respectively, added salt to the food at the end of cooking. Others added salt to the food during cooking (18.8% and 23.3% of pregnant and lactating women, respectively), only a few (1%) added salt to the food at the table. To ensure maximum iodine retention of salt, it is recommended that salt should be added to food at the table after the cooking process is finished (WHO/UNICEF, ICCIDD, 1996). The practice of adding salt to food at the beginning, during and at the end of cooking process was not appropriate as the iodine in salt and food is degraded due to exposure to prolonged heating and evaporation.

It was also noted that, about 45% (95% CI; 35.0%, 54%) and 54.5% (95% CI; 49.8%, 59%) of pregnant and lactating women, respectively, used an average of 30 minutes for cooking their food, while 30.7% and 19.4% of pregnant and lactating women, respectively, used an average of 1hour for cooking their food. Other women (23.9% of pregnant and 25.6% of lactating women) used an average of 15 minutes to cook food. There was significance difference in the average time used for cooking various foods ($p<0.05$). Iodine is volatile and therefore cooking without covering the cooking pot will result into evaporation of iodine leading to less iodine in food at the dining table (Diosady *et al*., 1997). This finally results to less iodine intake that will not meet human body requirement. Cooking for a long time at high temperature degrades iodine in food. Exposure of iodine to heat and moisture has been reported to enhance degradation of iodine (Diosady *et al*., 1997; WHO, 2001).

Majority of the women (96%) reported to cover the cooking pot while cooking. Only a few (4%) of them were not covering the pot while cooking. It was also reported that, majority of the women (95 % and 97.2 % of pregnant and lactating women, respectively) stored salt in containers with lids, while few of them (4.6 % and 2.8 % of pregnant and lactating women, respectively) stored salt in open containers. Elemental iodine readily sublimes and is then rapidly lost to the atmosphere. Covering the salt containers helps to retain iodine because iodine is hygroscopic in nature (Diosady *et al*., 1997).

Table 7: Cooking practices

	Pregnant n=218		Lactating n=211			
Parameters	**n**	**%**	**n**	**%**	**χ2**	**P-value**
Cooking methods						
Boiling	51	23.4	36	17.1	17.539	0.09
Frying	21	9.6	24	11.4		
Roasting	20	9.2	11	5.2		
Boiling and Frying	77	35.3	88	41.7		
Steaming	0	0.0	1	0.5		
Boiling and roasting	49	22.5	51	24.2		
Total	**218**	**100.0**	**211**	**100.0**		
When do you put salt to food						
Initially while cooking	94	43.1	96	45.5	8.983	0.000
During cooking	41	18.8	49	23.2		
At the end while cooking	82	37.6	65	30.8		
At the table	1	0.5	1	0.5		
Total	**218**	**100.0**	**211**	**100.0**		
Average time for cooking						
15min	52	23.9	54	25.6	13.176	0.000
30min	98	45	115	54.5		
1hr	67	30.7	41	19.4		
Not sure	1	0.5	1	0.5		
Total	**218**	**100.0**	**211**	**100.0**		
Salt stored in tight container						

Yes	208	95.4	205	97.2	0.275	0.26
No	10	4.6	6	2.8		
Total	**218**	**100.0**	**211**	**100.0**		

4.6 Knowledge of Iodated Salt by Salt Traders

It was observed that, 50% (95% CI; 36.0%, 63.8%) of salt traders had attained secondary school education, 35% had attained primary education while 10% had no formal education. About 90% of wholesalers had heard of iodated salt while 10 % had never heard about it. Likewise, 85% of retailers had heard about iodated salt while 15% of them had never heard about iodated salt. More than 95% could identify iodated salt by testing as most of wholesalers they had test kits and also by reading at the labels on the packaging materials. About 80 % of salt traders had heard of iodine deficiency disorders and were able to mention the common features of a person with IDD. Some of the features that salt traders mentioned included tiredness (25 %), goiter (35 %) and mental disabilities (25 %). Only 15 % of salt traders were not able to mention correctly the signs of IDD. They got the information through media (85 %), posters (10 %) and consumers (5%). From these findings it was obvious that wholesalers and retail traders were aware of IDD and had knowledge about iodated salt. A study done by Mosha *et al*. (2004) revealed that, the majority of surveyed households (66%, n=496), retail and wholesale shops had good salt handling practices that minimized iodine losses. A study done by Dragana *et al*. (2006) revealed that, the best knowledge of IDD was found among salt producers and salt traders. Increase public awareness among individuals, salt producers and salt traders was one of the effort that government had implemented through TFNC and TFDA in the course of food inspection (TFNC, 2006).

4.7 Iodine Status of the Pregnant and Lactating Women

Table 8 shows that, 34.6 % (95% CI; 16.0%, 52.9%) of the pregnant women had iodine status (>500 μg/l) while 15% (95% CI; 2.0%, 27.0%) of lactating women had iodine status exceeding the safety levels (>500 μg/l. About 28.6 % (95% CI; 17.0%, 39.8%) of pregnant women and 35.5% (95% CI; 24.0% 46.0%) of lactating women, had optimal iodine status of range (150-249 μg/l). It was also noted that, 19.8% of pregnant women and 48.8% (95% CI; 39.0%, 58.0%) had mild iodine status of range (50-150 μg/l). About 11.1% of pregnant women and 21.3% of lactating women had moderate iodine status of range (<20-49 μg/l). Only few of pregnant women (6%) and lactating women (12.3%) had severe iodine status of less than 20 μg/l. Urinary iodine concentration was statistically different between pregnant and lactating women($p<0.05$). Excess iodine intake may lead to thyroiditis, goiter, hypothyroidism, hyperthyroidism and sensitivity reactions.

Exposure to excess iodine during pregnancy may lead to transient hypothyroidism in newborn infants (Zimmermann *et al.*, 2005). Previously published reports have described both subclinical and overt thyroid dysfunction as a result of excess iodine ingestion (Pearce *et al*., 2002). Goiter, hypothyroidism, and/or a rise in serum TSH values have been reported to result from ingestion of excess iodine. Pearce *et al*.

(2002) demonstrated a high rate of thyroid dysfunction and goiter attributable to excess iodine from their water filters. Specific population groups like pregnant and lactating women require higher iodine levels than recommended for normal healthy adults. They should have median urinary iodine concentration in the range 200-249 µg/l (Assey, 2009).

Table 8: Iodine status of pregnant and lactating women

	Pregnant women		Lactating women	
Iodine status	n	%	n	%
<20 (Severe)	13	6	26	12.3
<20-49 (Moderate)	24	11.1	45	21.3
50-150 (Mild)	43	19.8	103	48.8
150-249 (Optimal)	62	28.6	75	35.5
>500 (Excess)	75	34.6	33	15.6
Total	**217**	**100**	**211**	**100**

More than two thirds of the 65 billion people living in countries affected by iodine deficiency now have access to iodized salt. Iodine excess is occurring more frequently, particularly when salt iodine levels are too high or are poorly monitored. For example, in Brazil, Armenia, and Uganda, median UIC is more than 300 µg/L, whereas in Chile it is above 500 µg/l. Increase in UIC has also been reported in other countries such as Niger, Zimbabwe, Cameroon, and Democratic Republic of the Congo. This has been attributed to excessively iodine intake above the WHO recommendations (Delange, 1999).

Iodine intake is more than adequate, (with a median UIC between 200 and 299 µg/l) in 24 countries. According to WHO (2004) there is emerging risk of iodine-induced hyperthyroidism in susceptible groups following introduction of iodized salt. Five countries such as Kenya, Uganda, Zimbabwe, Niger and Tanzania have reported a median UIC equal to or above 300 μg/l indicating excessive iodine intake and are therefore exposed to the risk of hyperthyroidism as result of iodine toxicity. Elevated median UI is most likely due to high levels of iodine added to salt. Salt quality monitoring should be re-inforced to ensure that the level of salt fortification with iodine is not too high but is adequate to ensure optimal iodine nutrition (Zimmermann *et al*., 2005). Two scenarios causing excessive iodine intake were observed in the study which was done in Tanzania and Ethiopia. People living close to salt factories and commercial centres with access to iodated salt direct from the factory that has not passed through the steps in the salt marketing chain that are known to cause iodine loss. Examples include commercial cities of Dar es Salaam, Arusha and Mwanza. These same regions have access to marine/lake seaweeds and fish. Excessive iodine intake is sometimes seen in these regions could be attributable to high frequency of food intake spiced with iodated salt such roasted meat and bakery foods which in many cases are popular in these big cities. It is sometimes seen in areas that receive salt from Kenya, a country where excessive UIC has also been reported. It was also reported that, population living close to Mombasa, Kenya such as Hai and Simanjiro districts had high iodine level (Assey *et al*., 2009).

The high UIC levels could also be attributed to iodation concentration which Tanzania originally set at 75– 100 ppm and now 40-80 ppm iodine at factory level, still over twice of the WHO recommendation (20 –40 ppm). Following training and supplies given to small scale salt producers the mean and median iodine concentration salt samples are currently at 33-85.2 ppm (TFNC, 2006). A study conducted in 27 goiter endemic districts in 1999, revealed varied iodine concentration in Tanzania, few samples had iodine concentration exceeding 100 ppm. However, more than 56 percent of studied subjects had urine iodine concentration above 200μg/l. A reduction in iodization levels from 75–100 ppm to 40–80 ppm was recommended to rectify the situation (Assey *et al*; 2009). Improved distribution, packaging and handling of iodated salt has probably reduced iodine losses, making such high iodine content at factory levels inappropriate in future (Assey *et al*., 2009). Proportion of 34.6% of women in study group that had showed excess iodine intake is similar to that of >30% reported in other countries in the Eastern Africa region (UNICEF, 2007). Inadequate quality control of iodation at salt producing factories may contribute to the problem. It is likely that lower factory salt iodation levels that have recently been harmonised to 40 – 60 ppm in the Eastern and Southern Africa (ECSA) region when adopted in member states, will reduce the prevalence of excessive iodine intake (UNICEF, 2007). High UI levels have been associated with increased risk of iodine-induced hyperthyroidism. Irrespective of age or sex, it would appear that most Tanzanians now fall within the normal range of iodine intake and excessive intake of iodine is emerging problem that need serious attention. Efforts to watch and treat diseases related to excess iodine should therefore become an integral part of the national IDD control program (Assey *et al*., 2009).

A survey conducted among refugees in Kakuma camp in Kenya showed a high median UI concentration (620 μg/l), suggesting that iodine consumption was more than adequate. In Uganda, a 2001 survey among long-term refugees in the Acholpii camp showed a median UI concentration of 726 μg/l (range: 150–3400 μg/l). UI Concentrations for all adolescents studied were also over the 100 μg/L deficiency cutoff point. The data available from refugee settings in Ethiopia, Kenya, Uganda and Zambia suggest there was excessive iodine intake (Natalie and Charlotte, 2009). In China, chronic excess iodine intakes are associated with a small increase in subclinical hypothyroidism and autoimmune thyroiditis, but not overt hypo- or hyperthyroidism. (Natalie and Charlotte, 2009). Conversely, in Denmark, correcting mild-to-moderate deficiency modestly increased rates of hypo- and hyperthyroidism. The differing effects of varying iodine intakes in these studies could be related to differences in underlying thyroid autonomy, genetic susceptibility, or other environmental variables (Zimmermann, 2007).

4.7.1 Urinary Iodine Concentration (UIC)

Table 8 show the urinary iodine concentration from pregnant and lactating women in the study area. During pregnancy, a median UIC of <150 µg/l indicates insufficient iodine intake, UIC of 150-249 µg/L indicates adequate intake, UIC of 250-499 µg/l implies that intake is more than adequate and UIC of 500 µg/L or higher indicates excessive iodine intake (WHO, 2007).

The overall median UIC for pregnant women (33%) was 205 µg/l (95% CI; 26.7%, 39.2%), and lactating women (22.8%) was 155.5 µg/l (95% CI; 17.1%, 28.4%). Median UIC for pregnant women (62.9%) in Themi was 122 µg/l (95% CI; 46.6%, 79%), while median UIC for lactating women (28.2%) was 178.1 µg/l (95% CI; 20.8%, 35.5%). The median UIC for pregnant women (36.5%) at Ngarenaro was 233.9 µg/l (95% CI; 29.5%, 43.4%), while median UIC for lactating women 39.2% was 123.5µg/l (95% CI; 27.6%, 50.7%).

Based on the results above, the pregnant women from Themi clinic had mild iodine deficiency (UIC=122 μg/l), but the lactating women had optimal iodine intake (UIC=178.1 μg/l). Pregnant women from Ngarenaro clinic had optimal iodine status (UIC=233.9 μg/l) while lactating women had mild iodine deficiency (UIC=123.5 μg/l). There is no much of physical difference in these two areas. Both Themi and Ngarenaro are located in urban and most of the food and other items they consume are obtained in a common market Arusha or Kilombero. However, Themi has higher socio-economic profile than Ngarenaro.The observed fluctuations of urinary iodine level could be due to variability in cooking practices that were observed in this study. Long time of cooking, poor salt storage practices, adding salt to food before or during cooking may have led to iodine degradation. A study done by (Mosha and Sakina, 2009) in Kilosa and Mufindi revealed that, pregnant women had median urinary iodine concentration of 155.5 μg/l which was above lower cut- off point (<150 μg/l) indicating that pregnant women had adequate iodine status. Likewise, more than 70% of lactating women had a median urinary iodine concentration of 188 μg/l, indicating adequate iodine status. The median urinary concentration between pregnant andf lactating women was statistically different ($p<0.05$). Findings in this study suggested that, despite the variations in amount of iodine consumed by subjects, pregnant and lactating women had sufficient iodine intake. This affirms the effectiveness of Government's efforts to control iodine deficiency disorders through universal salt iodations (Pardede *et al.*, 1998). Study which was done by (Assey *et al.*, 2009) demonstrated a marked improvement in iodine nutrition in Tanzania, twelve years after the initiation of USI.

Table 9: UIC (μg/l) of pregnant and lactating women

Population group	Themi	Ngarenaro	Overall
Pregnant (n=218)	122	233	205
Lactating (n=211)	178	123	155.5

4.8 Moisture Content in Salt

Out of the 428 salt samples determined for iodine content, 10% of the samples (95% CI; 1%, 18.9%) was sub sampled and analysed for moisture content. The median moisture content obtained was 0.9% (range 0.06 to 2.4%). The Tanzania's salt iodation regulations requires salt to have moisture content that should not exceed more than four percent of the weight of the undried sample (TFDA, 2010). Based on the moisture content findings the salt consumed at household level in this study area meets the requirement for good iodated salt factor that cannot influence losses of iodine. Moisture has been reported to be a major catalyst for iodine degradation in salt (Diosady *et al.*, 1997).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the urinary iodine concentration results of the study, it can be concluded that, there is excessive intake of iodine among the pregnant and lactating women. This suggests that salt which is used contain high amount of iodine or there is high frequency of intake of iodine containing foods that has resulted into increased proportion of subjects indicating excess iodine intake. Possible reasons for excessive iodine intake from salt could be due to high iodations levels at factory level, improved distribution system, salt packaging, especially for the people living close to salt factories and ports of entry. Other reasons are impeoved salt storage practices, which ensure maximum iodine stability. The recommended nutrient intake is intended to be used as a guide for the daily intake of iodine by individuals. Introduction of iodated salt to a situation where most of population consume iodated salt is a huge success in reducing the magnitude of IDD is reduced. However, the main challenge is to balance between the IDD reduction and excessive iodine intake preventing objectives.

5.2 Recommendations

- Monitoring iodine status in the population and conduct risk assessment for excessive consumption of iodine.

- The national IDD control programme in Tanzania needs to strengthen the quality control of salt iodation to avoid excessive iodine intake.
- To increase frequency of monitoring of salt at production, point of entry and at consumer level concurrent to ensure compliance with the preset limits for iodine
- The Ministry of Health and Social Welfare are required to initiate monitoring and evaluation to assess risk of excessive iodine intake in salt with a view to renew the current iodine limits set for salt.
- The Ministry of Health and Social Welfare are required to include urine iodine test among test undertaken by all mothers and child clinic for pregnant and lactating women..
- The Governmemt (TFDA and TFNC in particular) needs to continue providing education on importance of salt iodations and effects of IDD.

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APPENDICES

Appendix 1: Questionnaire for Pregnant and Lactating Women

Section A: Demographic Information

1. Date of interview..
2. Ward...
3. Name of the mother…………………………………………………………..
4. Maternal status 1. Pregnant 2. Normal 3. Lactating
5. Age of mother……………..(yrs)

6. Marital status? 1. Married 2.Single 3. Divorced 4.Cohabit

7. Education level (number of years gone to school). Mother…………

8. Occupation of the mother? 1. Farmer 2.Self employed 3.Paid employed 4.Casual labour

5. Others (Specify)……………….

9. Parity.................................... Age of the youngest child.............................

10. Family size (including yourself)…………… Children............... Adult...............

Section B: Salt iodations awareness

11. Ever heard of iodated salt? 1. Yes 2. No 3. Not sure

12. If yes where..

13. Can you identify iodated salt? 1. Yes 2.No 3. Not sure

14. If yes how? ....

15. Have you heard of iodine deficiency disorders? 1. Yes 2. No 3. Not sure

16. If yes where? ....

17. What are the sign of IDD's?

    1.Goiter 2. Mental retardation 3. Abortion and stillbirth 4.Tiredness 5. Growth retardation 6. Brain damage

18. Do you use salt in your food? 1. Yes 2. No

19. If yes where do you get your salt? 1. Shop 2. Local market 3. Locally made 4. Other (specify)..

20. Which type of salt did your household use in past 3 months? 1. Iodated 2. Non iodated 3. Salt substitute 4 Not sure

21. What factors affect your choice of salt during purchasing? 1. Price 2. Availability 3. Location 4.Tradition 5. Taste 5. Other (specify)..

22. In which form of package do you usually purchase your salt? 1. Cups 2. Packets 3. Other..

23. Do you prefer course or fine salt? 1.Course 2.Fine

24. What are the reasons for your preference……………………………………………….

25. How do you store your salt at home?

Section C: Cooking practices

26. Can you mention your usual cooking style?

27. At what time do you put salt while cooking? 1. At the beginning while cooking 2. During cooking 3. At the end while am cooking 4. At the table 5. Other (specify)

28. When cooking, do you cover the pot? 1. Yes 2. No

29. How much time on average do you use for cooking? 1. 15min 2. 30min 3. 1 hr 4. Above 1 hr 5. Not sure

30. How do you store your salt in the household? 1. Plastic container 2. Tin container 3. Paper 4. Other (specify)...

31. Does the container has a lid? 1. Yes 2 No

Appendix 2: Questionnaire for Salt Traders (Wholesale and retail)

Section A: Demographic Information

1. Date of interview...
2. Ward..
3. Name of the trader…………………………………………………………..
4. Age of trader……………..(yrs)
5. Education level (number of years gone to school) trader.…………..
6. Occupation of the trader? 1. Wholesale 2.Retail 3.Paid employed 4.Casual labour 5.Others (Specify)……………….

Section B: Salt iodations awareness

6. Ever heard of iodated salt? 1. Yes 2. No 3. Not sure

7. How do you identify iodated salt? 1. Iodated salt emblem 2. Written on packet/bag

3. Reading on label 4. Others (specify)

8. Can you identify iodated salt? 1. Yes 2.No 3. Not sure

9. Have you heard of iodine deficiency disorders? 1. Yes 2. No 3. Not sur

10. If yes what are the common feature of a person with IDD 1.Goiter 2. Mental retardation 3. Abortion and stillbirth 4.Tiredness 5. Growth retardation 6. Brain damage

11. How did you learn about IDD? 1. Posters/Billboards 2.Leaflets 3. Radio 4. Newspape 5.Others (specify)

12. Is salt you currently selling iodated 1. Yes 2. No 3. Not sure

13. Did you ever sell salt which is not iodated? 1. Yes 2. No 3. Not sure

14. Why are you currently still selling non iodated salt 1. People preference 2. Easy to sell 3.Easy to handle 4. Easy to sell 5. Other (specify)

Consent Form

Appendix 3: Explanation given to pregnant and lactating women concerning the study

1. **Purpose of the study:** This research is going to determine the iodine status of pregnant and lactating women. The main objective of the study is to assess the iodine status of these women. Specific objectives are; determine iodine concentration in salt consumed by pregannt and lactating women, determine the iodine concentration in urine samples and to determine cooking and salt handling practices and how these practices affect iodine stability or loss. This study is done in collaboration with Sokoine University of Agriculture department of food science and technology at Morogoro region

2. **Study procedure**: If you agree to participate in this study, please respond to my questionnaire and provide the required information. I will ask your permission for you to provide a salt that you use and urine sample for laboratory analysis.

3. **Risk and discomfort:** No risk and any discomfort for you to participitate in this study.
4. **Benefits:** Benefits will be observed after the result in laboratory analysis that will help to know if the salt you consumed is iodated or not and to know your iodine status.
5. **Compensation:** You will not be given any allowances for you to participating in this study.
6. Confidentiality: confidentiality will be maintained.

Statement of consent

I have read the above information or it has been read to me. I have had the opportunity to discuss this research study with researcher, and I have had my questions answered by her in a language I understand.

Agreement to take part in the study:

Name of a mother	**Signature/thumb print**	**Date**
……………………..	………………………	……………………
Name of researcher	**Signature/thumb print**	**Date**
………………………	………………………………	……………………