ASSESSMENT OF IODINE STATUS OF SCHOOL CHILDREN, PREGNANT AND LACTATING WOMEN IN MUFINDI AND KILOSA DISTRICTS, TANZANIA

BY

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ABSTRACT

This study was conducted to assess iodine status of school-aged children, pregnant, lactating and normal women in Rungemba, Kitelewasi, Kinyanambo and Berega villages. Data were collected by using a structured, pre-tested questionnaire. Urine and salt samples were collected and analyzed to determine iodine concentrations. Anthropometric measurements including weight and height and records of age, sex and gestation age for the pregnant women were also taken. Data were analysed by using EPI info and SPSS statistical package for window programs. Results showed that, the median urinary iodine concentration for schoolchildren were 132.7 µg/L (boys) and 96.3 µg/L (girls). For pregnant, lactating and normal women, median iodine concentrations were 188.6, 155.7 and 258.4 µg/L, respectively. More than 80% (n = 135) of salt samples collected from the households had iodine concentration levels in the range of 20-50 ppm, while 15.6% (n = 135) had iodine concentrations below 20 ppm. This implied that, iodine concentration in most of the salt samples was adequate. Results also revealed that, 30.9% (n = 144) of schoolboys and 32.3% (n = 127) of schoolgirls had normal weight for age while 4.2% (n = 144) of schoolboys and 4.7% (n = 127 of schoolgirls were severely underweight. Majority 97.3% (n = 144) of schoolboys and 96.9% (n = 127) of schoolgirls had normal weight for height. Likewise, 4.3% (n = 139) of pregnant, 41 % (n = 139) of lactating and 22.3% (n = 139) normal women had BMI within the normal range (18.5 - 24.99) while 0.7% (n = 139) of pregnant, 12% of lactating, and 8% of normal women were overweight. Nutrition education on effects of iodine deficiency disorders and quality control of iodine levels in salt at district and local levels is important to ensure that adequate iodine is reaching the people.

DECLARATION

I, SAKINA HASSAN do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and has never being submitted for a higher degree award in any other University.

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The above declaration is confirmed

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PROF. T.C. E. Mosha Date

(Supervisor)

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DEDICATION

I would like to dedicate this work to the Almighty **God** for granting me life, the ability to study from the beginning up to this level and to my lovely parents Mwl. N. H. Shegwando and Mrs. Z.E. Madiwa who laid the foundation of my education.

TABLE OF CONTENTS

Table 4 data showed that, the median urinary iodine concentration of schoolboys (7 -8 years) in Kitelewasi village was 101.2 μg/L, whereby six schoolboys aged 9-10 years had urinary iodine concentration in the range 50 - 99 μg/L, three schoolboys (9-10 years) had urinary iodine concentration in the range 100 - 200 μg/L (adequate iodine concentration). Results revealed that, 10 schoolgirls (9 - 10 years) had adequate iodine concentration range of 100 - 200 μg/L, while eight schoolgirls (9-10 years) had mild (51 - 99 μg/L) iodine deficiency and one schoolgirl had severe iodine deficiency (< 20 μg/L). Median urinary iodine for schoolboys in Rungemba village was 79 μg/L and for schoolgirls was 107.7 μg/L (Table 4). Results showed that, in Rungemba one schoolboy aged 7-8 years had severe iodine deficiency (< 20 μg/L), four schoolboys (7 - 8years) had moderate iodine deficiency and six schoolboys (7 - 8 years) had mild (51 - 99 μg/L) iodine deficiency. Result also showed that, three schoolboys (9 - 10 years) had

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CSPD	-	Child Survival Program and Development
FAO	-	Food and Agriculture Organization of the United Nations
ICCIDD	-	International Council for the Control of Iodine Deficiency Disorders
IDD	-	Iodine Deficiency Disorders
IOM	-	United State Institute of Medicine
JNSP	-	Joint Nutrition Support Program
NCHS	-	National Center for Health Statistics
PAMM	-	Programme Against Micronutrient Malnutrition
TBS	-	Tanzania Bureau of Standards

TFDA	-	Tanzania Food and Drugs
TFNC	-	Tanzania Food and Nutrition Centre
TSH	-	Thyroid Stimulating Hormone
UNICEF	-	United Nation International Children’s' Education Fund
URT	-	United Republic of Tanzania
USADA	-	United States Department of Agriculture
USIM	-	United State Institute of Medicine
WHO	-	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Iodine deficiency constitutes one of the major public health problems in Africa, with more than 180 million people at a risk of iodine deficiency disorders (ICCIDD, 1997). Iodine deficiency is the main cause of preventable mental retardation. Iodine deficiency disorders include goiter and cretinism. Iodine deficiency disorder is a threat to more than 200 billion people who live in areas where the soils are iodine deficient and the estimated number of affected population in Africa is 124 million. With the impressive levels of salt iodization and increased consumption of iodized salt at the household level, it is estimated that, globally, the number of children with mental deficiencies due to lack of iodine has decreased from 40 to 28 million. In Africa, IDD prevalence rates and clinical manifestations are less florid than on some other continents. IDDs continue to cause a significant loss of potential cognitive development to many infants born to mothers living in endemic areas in Africa (Zein, 2002).

In Tanzania it is estimated that, 7.5 million people are affected by IDDs (URT/UNICEF, 1990; Kavishe and Mushi, 1993; Francesconi *et a*l., 1996). A nation-wide survey on the prevalence of goiter revealed that, both total and visible goiter rates were very high at 71.8% and 36.5%, respectively. About 30% of prenatal mortality in Tanzania was attributed to IDD. IDD is most severe in highland areas with persistent rainfall and in lowland areas prone to floods. The severely affected regions are also the most agriculturally productive and export foods to the iodine sufficient areas (Kavishe, 1994). The most affected regions in Tanzania are Kigoma, Kilimanjaro, Kagera, Morogoro, Iringa and Arusha. However, food exports from the affected areas may be low in iodine due to leaching that depletes the soil of its iodine content. For this reason goiter prevalence varies enormously, due to differences in soil geology and water supplies (Burgi *et al*., 1990).

The serious impact of IDD upon the health and development of individuals and society, led to Organizations such as WHO/UNICEF to pass the resolution for elimination of IDD by the year 2000, however, the problem is still persistent. This was shown by a survey carried out in 23 districts of Tanzania, which revealed that, the average total goiter rate was 43.2% for male and 52.6% for females with an average prevalence of 47% (Kavishe, 1993).

1.2 Assessment of Iodine Status

Various indicators are used for measuring iodine deficiency. All of these indicators however, reflect different aspects of iodine deficiency. There is no single indicator that fully represents iodine status. Indicators may be related to iodine intake, to iodine dependent endocrinological processes in the human body (outcome indicators) or to progress made with respect to provision of households with sources of iodine, such as iodized salt (process indicators) (WHO/UNICEF/ICCIDD, 1994). This study will measure iodine status by using outcome and process indicators by determining iodine concentration in urine and salt samples, respectively for samples collected from the most vulnerable social groups (school aged children, pregnant, lactating and normal mothers) living in goiter endemic areas of Tanzania.

Measurement of iodine in urine provides a good proxy for recent iodine intake, as most iodine is eventually excreted in urine following deiodination of the thyroid hormones. However, the amount of iodine excreted by an individual varies from day to day as well as during the day. It is thus recommended that, the results obtained be used for making an estimate of iodine status of population groups rather than the iodine status of individuals (WHO/UNICEF/ICCIDD, 1994). Urinary iodine concentration (expressed as μg/L of urine) is preferably used rather than urinary iodine excretion (expressed as μg/L of creatinine), because iodine expressed per gram of creatinine is not reliable in areas where protein intake (and thus creatinine excretion) is low (WHO/UNICEF/ICCIDD, 1994). The choice of process indicator for iodine status is influenced by the specific intervention programme. It is most suitable for programmess intended for improving availability and consumption of iodized salt by subjects who are at high risk of iodine deficiency (WHO/UNICEF/ICCIDD, 1994).

1.3 Problem Statement and Justification

In Tanzania, iodine deficiency is found to be endemic in the Southern Highland districts, but villages in other districts in the Northeastern, Central and Northwester areas are also affected. Although significant gains have been made in fighting iodine deficiency in the country, iodine deficiency remains a public health problem. Iodine deficiency disorders have been recognized as the leading cause of intellectual impairment worldwide (Ramaligaswami, 1992). Development of the central nervous system for normal intellectual functioning depends on adequate supply of thyroid hormones, which require iodine for biosynthesis. Furthermore, high rates (about 0.5

to 1%) of neonatal deaths and stillbirths are associated with maternal iodine deficiency in regions where people have sub-optimal iodine intakes. Severe iodine deficiency in pregnant women leads to irreversible mental retardation and neurological disorders (cretinism) in their progeny. Other iodine deficiency disorders include deafness, muteness, and mild to moderate mental retardation that are all irreversible. They limit children's ability to learn and comprehend, hence their educational attainment, occupational choices and ultimately, their future livelihoods and welfare (Marberly *et al.,* 1994). Mild iodine deficiency has been reported to reduce intelligence quotients (1.Q) by 10 - 15%. Iodine deficiency also reduces working capacity and hence economic well-being at both household and national levels (Marberly *et al.,* 1994).

In light of the foregoing, this study was designed to assess the iodine status of school-aged children, pregnant and lactating women in Kitelewasi, Kinyanambo and Rungemba villages of Iringa region and Berega village of Morogoro region. These villages were involved in the Iringa Nutrition Programme (JNSP) and Children Survival Program and Development (CSPD) more than 20 years ago. This study will help to obtain the iodine status of vulnerable population in the INP programme areas, assess sustainability of iodine elimination programme and will serve as a basis for advising the government on appropriate action to be taken.

1.4 Objectives

1.4.1 General objective

To assess iodine status of school aged children, pregnant and lactating women.

1.4.2 Specific objectives

1. To assess the awareness on dietary sources of iodine, iodine deficiency disorders and the use of iodized salt.
2. To determine urinary iodine concentration of school children, normal, pregnant and lactating women
3. To determine the concentration of iodine in salt used in the surveyed households
4. To determine the nutritional status of school children.
5. To determine the nutritional status of normal, pregnant and lactating women.

CHAPTER TWO

LITERATURE REVIEW

2.1 Food sources of iodine

The iodine content of foods and of total diets differs appreciably and is influenced by geochemical, soil and cultural conditions, which modify the iodine uptake of staple crops and of animals. Generally, vegetables are low in iodine because the iodine content of a given plant food depends on the type of soil (Dunn, 1992). Seawater contains iodine and when the sea spray is deposited on coastal regions it enriches the soil and the drinking water with iodine. Vegetables grown in coastal areas take up iodine from the soil and the inhabitants of coastal areas get iodine from vegetables and drinking water as well as from seafoods, which are the richest sources of iodine. The amount of iodine in animal products such as meat and eggs is generally good, but depends on the composition of animal feed (WHO, 2001; FAO/WHO, 2002).

2.2 Consequences of iodine deficiency

Deficiency of iodine results in a wide spectrum of illnesses collectively termed as iodine deficiency disorders (IDDs). Iodine can affect people at any age, but is particularly harmful in pregnant women, the developing foetus and the newborn babies (WHO, 1993, 1996, 2001). Iodine deficiency disorders reflect the importance of proper iodine intake for normal thyroid gland functioning. Iodine deficiency leads to hypothyroidism and the development of an enlarged thyroid gland, referred to as goiter (Delange, 1994). When the levels of iodine are low in the diet and in the blood, the entire thyroid gland swells. Adequate maternal iodine intake before and during gestation period therefore prevents iodine deficiency disorders (Het Zel *et al*., 1990; WHO, 2001; IOM, 2001).

These disorders are seen at all stages of development particularly the foetus, the neonate and the infant i.e. in periods of rapid growth. Iodine deficiency disorder is a major cause of children failure to reach their intellectual potential (Delange, 2004). Foetal survival and development are both sensitive to iodine deficiency. Brain development in the foetus and neonate is particularly affected by iodine deficiency (Delange, 1994, 2001). The disorders result from the influence of a low maternal thyroxine level on the foetus and are associated with levels of iodine intake less than 25% of normal. Levels less than 50% of normal are associated with goiter. All these disorders are fully preventable if the iodine deficiency is corrected before end of gestation period (Azizi, 1993, 1995; Fenzi, 1990; Ares, 1994; Tiwari, 1996; WHO, 2001).

2.3 Inhibitors of iodine absorption

The recommended level of iodine intake is 100-150 μg /day. This level is adequate to maintain the thyroid gland function, which is essential for normal growth and development. In the presence of goitrogens in the diet, the intake should be increased to 200-300 μg /day. Goitrogens are found in a number of staple foods consumed in developing countries, including cassava, maize, bamboo shoots, sweet potatoes, lima beans and millet (Robert, 1998). Goitrogens are derived from cyanogenic glycosides, which are capable of liberating large quantities of cyanide on hydrolysis. Not only is cyanide itself toxic, but its metabolite in the body is predominantly thiocyanate, which is a goitrogen. Goitrogens that are natural inhibitors of thyroid gland function can promote the development of goiter. When eaten in large quantities on a regular basis, can lead to thyroid problems by reducing the amount of available iodine for the biosynthesis of thyroid hormones. Cooking inactivates the goitrogens (WHO, 2001). With exception of cassava, these glycosides are located in the edible portions of the plants, in small amounts and thus do not cause major problems (Groff *et al*., 1995; FAO, 1996; IOM, 2001).

2.4 Toxicity of iodine intake

Iodine intake in large amounts (more than 50 mg/day) disturbs all thyroid functions starting from the transport of iodine to the synthesis and secretion of thyroid hormone. Excessive iodine therefore works like a goitrogen and can cause iodine deficiency goiter (WHO, 1996, 2001). Excess amounts of iodine can also cause acne-like skin lesions or can worsen pre-existing acne of preadolescents or young adults. Lododerma is the term used for nodular, ulcerating, pustular, or fungating lesions that occur on the skin of some individuals after long-term ingestion of excessive iodine (usually from expectorants). Similar signs are also seen in those who eat seaweeds as a dietary supplement (Dunn, 1992).

2.5 Social-economic and demographic factors affecting iodine intake and status

Thyroid gland function is affected by various physiological conditions, for instance food scarcity (Schroder Van der Elst, 1992), pregnancy (Glioer *et al.*, 1990) and iodine deficiency (Versloot *et al*., 1997).

During pregnancy, the thyroid is subjected to increased demand, which increase the risk for iodine deficiency. Pregnancy is accompanied by a rise in thyroxine hormone (T4-binding globulin) and total thyroxine hormone (T4) and tri-iodothyronine hormone (T3) (Glinoer, 1990). However, the level of free thyroxine hormone decreases at the end of gestation period. In iodine deficiency areas, pregnancy discloses the underlying iodine deficiency with maternal and neonatal goitre formation and subsequent physical and intellectual impairments which are easy to prevent by iodine supplementations (Glinoer *et al*., 1995, 2001; Liesenkopel *et al*., 1996; Smyth *et al*., 1997). Iodine requirements are therefore increased during pregnancy to provide the needs of the foetus and to compensate for increased loss of iodine in the urine resulting from an increased renal clearance during pregnancy. The increase in iodine requirements has been reported from studies of thyroid function during pregnancy and in the neonate under conditions of moderate iodine deficiency (FAO/WHO, 2002). Studies also indicated that, increased intake of iodine is required to prevent the onset of sub-clinical hypothyroidism of mother and foetus during pregnancy, and thus to prevent the possible risk of brain damage of the foetus (FOA/WHO, 2002).

Physiological functions of thyroid hormone and urinary iodine excretion return to normal during lactation period, but iodine is concentrated in the mammary gland for excretion in the breast milk. So using the urinary iodine concentration to estimate intake during lactation may lead to underestimation of iodine requirements (ICCIDD, 2007).

A major factor influencing food consumption is income, which is associated with occupation. When individual's income is low, there would be a problem of money to purchase food adequately for all households members, thus leading to inadequate iodine intake and consequently iodine deficiency disorders especially among children and women (Robert, 1996). For most of the world's hungry people, the major determinant of their hunger is poverty or inadequate household income. In 1990, this was the case for about 15% of the world's population or more than 780 million people. Therefore, improving the productivity of low-income agriculture in developing countries not only provides broad-based income and employment opportunities but also supplies more food and nutrients (Robert, 1996). Iodine deficiency disorders appear in all ages of life depending on iodine supply (Nills *et al*., 2002).

2.6 Gender differences in iodine deficiency

Evidence from multiple sources indicates gender differences in iodine deficiency. A number of practitioners have noted that, IDD is systematically higher among female than among male adolescents (Allen *et al*., 2001). A relatively consistent global pattern indicates that, females are more likely to develop goiter than males and goitrous females are more likely to suffer from severe goiter when compared to goitrous males (Simon, 1990). These results which are based on observational studies have a limitation that, they cannot distinguish between gender differences arising from sex-specific dietary patterns and physiological differences between males and females. A more conclusive evidence of biologically-driven gender differences in iodine sensitivity comes from a recent laboratory experiment of maternal thyroid deficiency in rats, which found that, the effect of artificially restricting maternal thyroid hormone transferred in utero on fetal neurodevelopment and behavioral outcomes was significantly larger in female progeny (Friedhoff *et al*., 2000). Despite the fact that thyroid conditions of all types are consistently higher among females than males; the same study noted that, “few (laborator) studies have addressed the role of biochemicals of maternal origin on sex differences in fetal neurodevelopment and behavioural outcomes.” Although the biological pathway is not fully understood, the finding is possibly related to differences between males and females in the onset of fetal thyroid production, and resulting gender differences in dependency on maternal thyroid transfers (Friedhoff *et al*., 2000).

2.7 Iodine deficiency disorders and their effects

Iodine is necessary for the thyroid hormones that regulate growth, development and metabolism and is essential to prevent goitre and cretinism (Laura, 2006).

2.7.1 Iodine deficiency disorders effect on nutritional status

The mechanism of IDD in the setting of three indicators of protein-energy under-nutrition (PEU) i.e stunting, wasting and underweight is probably multi-factorial. In PEU children, negatively charged iodine is less absorbed against the electrochemical gradient requiring energy (Sheela *et al*., 2001). Iodine concentration of the thyroid gland decreases due to depressed iodine clearance and uptake in PEU. Thus, PEU indirectly results in alteractions in iodine metabolism that may lead to hyperplasia and further reduces circulating thyroid hormone levels. Secondly, PEU contributes to goitrogenesis directly through the lack of substrate availability, in particular the lack of essential amino acids such as tyrosine (Polge, 1997). A study done by Sheela (2001) showed that, PEU was highly prevalent in mild to moderately iodine deficient school children and adults. On population basis, high levels of stunting have been associated with poor economic conditions and endemic goitre in rural settings.

Gibson (1990) indicated that, PEU can affect urinary creatinine concentrations. When this occurs, the measure of iodine status by urinary iodine excretion is altered.

2.7.2 Effect iodine deficiency disorders on development

Iodine exerts its function in the body only when it is incorporated into the thyroid hormones, thyroxine (T4) and Tri-iodothyronine (T3) (Delange, 2004). These hormones play an essential role in growth and development and in maintaining normal metabolism state of human beings and animals (Gibson, 1990). In health human beings, the thyroid gland weighs only about 15 - 25 g and contains approximately 15 - 20 mg of iodine, or 70 - 80% of the total amount of iodine in the body (Van den Briel-van Ingen, 2001). The physiological role of the thyroid hormones is to ensure the timely coordination of different developmental events through specific effects on the rate of cell differentiation and gene expression. Thyroid hormone action is exerted through binding of Triiodothyronine (T3) to nuclear receptors which regulate the expression of specific genes in different brain regions following a precise developing schedule during fetal and early post-natal life (Delange and Hetzel, 2006).

Lombardi *et al*. (1995) reported that, children aged 6-10 years with mild iodine deficiency (64 µg iodine/day), had delayed reaction time compared with matched controls from an iodine sufficient area (142 µg iodine/day). Investigations from other areas with moderate iodine deficiency have also demonstrated delayed psychoneuromotor and intellectual development of children and adults (Vermiglio *et al*., 1990, Vitti, 1992; Fenzi, 1990).

2.7.3 Effect of iodine deficiency disorders on cognition

Central nervous system development depends on an adequate supply of thyroid hormone, which requires iodine for biosynthesis. Thus, iodine is an essential micronutrient for normal intellectual development and functioning. Without the biologically required micro-quantities provided in the diet, mild to severe intellectual impairment and mental retardation may occur (Maberly, 1994). Insufficient supply of thyroid hormones to the developing brain of the fetus therefore can result in congenital abnormalies and intellectual impairment. Endemic cretinism is the most severe manifestation of the lack of maternal and fetal thyroid hormone arising from severe dietary iodine deficiency. The hallmarks of endemic cretinism include mental retardation and brain disorder characterized by pyramid signs in an upper limb distribution and extra pyramidal signs. These subjects have a diagnostic gait, which is not only related to the neurological disorder but contributed to joint laxity and deformity (Stanbury and Hetzel, 1994). Other frequently encountered clinical features include squiting, deafness, and primitive brain reflexes (Bleichrodt and Born 1994; Higdon, 2003; WHO/UNCEF/ICCIDD, 1994; Koibuch, 2000,). Furthermore, studies in both animals and humans have confirmed that maternal thyroxine hormone plays a very important role in fetal brain development before the fetus starts producing its own supply of thyroid hormone (Vulsma, 1996; Morreale *et al*., 1993) and the earlier view that the placenta is relatively impermeable to the transfer of maternal thyroid hormone has been revised (Pharaoh, 1995). In this context, maternal serum concentration of thyroxine hormone has been shown to correlate with outcome measures in children such as motor and cognitive function.

2.7.4 Effect of iodine deficiency disorders on mortality

Serious iodine deficiency leads to functional and developmental abnormalities such as hypothyroidism. Hypothyroidism causes physical and mental retardation in infants and children (FAO/WHO, 2002; IOM, 2001). In neonates, iodine deficiency increased the risk for perinatal and infant mortality due to low birth weights.

Boyanges (1993) observed that, in areas with severe endemic IDD, rates of miscarriage and infant mortality increased. Cretinism is rare, but populations in which severe iodine deficiency is prevalent are at risk of reduced intelligence and mental retardation. Indeed, iodine deficiency is the leading cause of preventable mental retardation worldwide.

Iodine deficiency causes an increased risk for aggressive thyroid cancers (i.e, follicular thyroid carcinoma). Increased thyroid cancer mortality rates are found in areas where iodine deficiency is endemic (WHO, 1993).

2.7.5 Effect of iodine deficiency disorders on morbidity

Iodine inactivates bacteria; hence it is used as a skin disinfectant and water purificant. Iodine also plays a role in the prevention of fibrocystic breast cancer diseases, a condition characterised by painful swelling in the breasts, by modulating the effect of the hormone eostrogen on breast tissue. Finally, researchers hypothesize that, iodine deficiency impairs the function of the immune system and adequate iodine is necessary to prevent miscarriages (Dunn, 2001; Delange, 2000 and Rasmussen, 2001).

Radioactive iodine, especially **I^{131}**, is released into the environment as a result of nuclear reactor accidents. Accumulation of radioactive iodine in the thyroid hormone increases the risk of developing thyroid cancer in children. The increased iodine trapping activity of the thyroid gland in iodine deficiency results in increased thyroid accumulation of radioactive iodine. Thus, iodine deficient individuals are at increased risk of developing radiation-induced thyroid cancer because they will accumulate greater amounts of radioactive iodine. Few case control studies address the influence of radioactive iodine on the other main disorders induced by iodine deficiency, such as impairment of thyroid function, low birth weight, perinatal mortality and morbidity and prevention of mental retardation. Overall, it appears that, correction of iodine deficiency decreases the risk of morbidity from thyroid cancer (Delange, 2000).

2.7.6 Effect of iodine deficiency disorders on reproduction

Iodine is an essential element for thyroid function, necessary for the normal growth, development and functioning of the brain and body. It also influences a variety of metabolic processes in the body (converting food to energy, regulating growth and fertility, and maintaining body temperature) (Roger, 2002).

Severe iodine deficiency in the fetal and neonatal period may lead to cretinism (Delange, 1994), which is characterised by stunted growth, mental and other neurological retardation, and delay in development of secondary sexual characteristics (FAO/WHO, 2002; Dummies, 2007). Also severe iodine deficiency decreases maternal fertility (Boyanges, 1993).

2.8 Assessment of iodine deficiency disorders

2.8.1 Bio-markers for measuring Iodine Status

Various biomarkers can be used to determine iodine deficiency. Indicators may be related to iodine intake, iodine dependent endocrinological processes in the human body (outcome indicators) or processes made with respect to provision of households with source of iodine, such as iodized salt ('process indicators') (WHO/UNICEF/ ICCIDD, 1994). The most widely used methods for measuring iodine deficiency are outcome indicators. Outcome indicators include clinical and bio-chemical indicators (May *et a l.*, 1997; Desai *et al.*, 1994).

2.8.2 Clinical indicators

2.8.2.1 Size of thyroid grand

In public health, the most widely used clinical indicator of iodine deficiency is the size of the thyroid gland, measured by palpation. Classification has been simplified from a system with 5 grades to a system with only 3 grades (WHO/UNICEF/ICCIDD, 1994).

Grade 0 = no palpable or visible goiter, Grade 1 = a mass in the neck that is consistent with an enlarged thyroid gland that is palpable but not visible when the neck is in the normal position, Grade 2= a swelling in the neck that is visible when the neck is in the normal position and is consistent with an enlarged thyroid gland when the neck is palpated. This method is still widely used as it is cheap and provides a quick way of assessing whether or not there is a problem of iodine deficiency. However, the specificity and sensitivity of this method, especially for grades 0 and 1 are low due to a high inter-observer variation. Thus the person carrying out the survey must be well trained on the use of ultrasonography which is a more accurate way of assessing the volume of the thyroid. Ultrasonogram equipment is also very expensive. Even with this method however, inter-observer variation may be high (Zimmeran and Spehl, 2001).

2.8.2.2 Endemic cretinism

Endemic cretinism is the most extreme form of iodine deficiency disorder that manifests itself in severe growth and mental retardation often accompanied by a deaf mutism (Boyange, 1993; Halpern, 1991).

Endemic cretinism has been well described and defined by a Pan American Health Organization study group and Delange (1994) in terms of two major features- epidemiology characterized by endemic goitre and severe iodine deficiency, clinical manifestations characterized by neurological syndrome consisting of hearing and speech defect and varying degrees of stance and gait disorders, or predominant hypothyroidism and stunted growth. Because cretinism is a clinical diagnosis of a disorder with a presentation spectrum from mild to devastatingly severe state, it is difficult to identify all of the affected individuals in a population. The more mildly affected cretins may not be diagnosed except by clinical experts or by using specialized methods, example audiometric or psychometric tests. Also, significant amount of time is needed to perform the necessary physical examination (WHO/UNCEF/ICCIDD, 1994).

2.8.3 Biological outcome indicators

Biological outcome indicators include concentrations of hormones in serum or whole blood and concentration of iodine in urine. The serum or blood indicators most commonly used are thyroxine, triiodothyronine, thyroglobulin and thyrotropin or thyroid stimulating hormone. Assessment of concentration of these indicators is however not readily done on a large scale due to the difficulty in collecting blood samples and the high cost of analysis.

2.8.3.1 Thyroid stimulating hormone (TSH)

Iodine is essential for synthesis of thyroid hormones, which are necessary for normal brain and neurological development (Gibson, 1990). The kinetics of the thyroid hormone receptor in the pituitary gland mimics the kinetics of thyroid hormone receptors in the brain. When iodine levels are low, the concentration of thyroid hormones in the pituitary gland stimulates the release of TSH, which can then be detected in the blood. Serum or whole blood TSH levels therefore reflect the availability and adequacy of thyroid hormone (WHO/UNICEF/ICCIDD, 1994).

Blood TSH concentration is widely used in neonatal screening programmes for congenital hypothyroidism and is also used for monitoring correct iodine deficiency at the population level (Delange, 1997); however, its usefulness in older population groups is uncertain. Moreover, assay methods and reference materials are not universally standardized implying that criteria and cut-off point are not universally applicable.

2.8.3.2 Thyroglobulin (Tg)

Insufficient iodine intake induces a proliferation of thyroid cells which results in cell hyperplasia and hypertrophy. This leads to an enhanced turn over of thyroid cells that release thyroglobulin into the serum. Thyroglobulin (Tg) in serum changes inversely with iodine intake in all age group. Thyroglobulin (Tg) level is a more sensitive indicator than TSH. Thyroglobulin rises in individuals with insufficient iodine intakes, even under conditions where TSH falls or is suppressed due to functional autonomy, as frequently happens with long-term iodine deficiency. After iodine depletion, Tg will rise before TSH shifts to higher values and long before goitre develops. Following iodine supplementation, thyroglobulin normalizes before thyroid volume has decreased. Individuals [children and adults] with sufficient iodine intake show a median thyroglobulin serum level of 10 ng/ml with upper limit of 20 ng/ml for normal individuals. The results obtained from a survey should be expressed as a median and as the percentage of thyroglobulin levels above 20 ng/ml (WHO /UNICEF/ICCIDD, 1994).

2.8.3.3 Urinary iodine excretion

Daily urinary excretion of iodine closely reflects iodine intake, and has been used as an index of iodine nutriture in many large-scale nutrition surveys (Gibson, 1990; Dunny, 1993; Pino, 1996). Urinary Iodine excretion (UI) analysis uses a modified acid-digestion method (method E), based on the reaction between Cerium IV and Aarsenic III (Sandell-Kolthoff Reaction) and uses a Technical Auto-analyzer II (May *et al*., 1997). The results are expressed as micrograms of iodine per liter of urine (µg/L). The method does not separate out the interfering substances, so they are removed from the urine samples to arrive at true urinary iodine value. The method is easy to perform, but meticulous attention is required to avoid contamination with iodine at all stages (Dunn *et al*., 1994). The indicator of iodine deficiency is median since iodine values from the population are not normally distributed. The cut-off points proposed for classifying iodine deficiency into different degrees of public health are < 20 μg /L indicates severe, 20 - 49 μg /L indicates moderate, 50 - 99 μg /L indicates mild iodine deficiency and levels above/equal to 100 μg /L indicates no iodine deficiency (Table 1) (WHO/ICCIDD, 2001).

Table 1: Summary of iodine deficiency prevalence indicators

		Severity of public problem (prevalence)			
Indicator	Target population	None	Mild	Moderate	Severe
Median urine iodine (μg /L)	School children	>100	50-99	20-49	<20
Thyroid volume	School children	<5%	5-19.9%	20-29.9%	>30%
TSH	School children	<3%	3-20%	20-40%	>40%
Cretinism	Children/ adult	0	0	Positive	Positive
Thyroglobulin	Children/adult	<10	10.0-19.9	20.0-39.9	40.0

WHO/UNICEF/ICCIDD (1993).

2.9 Uses of anthropometric measurements to assess the nutritional status

Nutritional assessment can be defined as the interpretation of information obtained from dietary, biochemical, anthropometric and clinical studies. Assessment is used to determine the health status of individuals or population groups as influenced by their intake and utilization of nutrients. Major methods available for field surveys are divided into two key categories: those that are food related and those that are related to health or people. The latter includes the major assessment technique of anthropometry.

Anthropometric indices provide measurable reflections of nutritional status and can help differentiate between chronic and acute undernutrition, stunting or wasting. The indicators most often used are body weight and height, in relation to age and sex. Other, less frequently used indicators include mid-upper arm circumference, head circumference, waist/hip circumference ratio and skin-fold thicknesses. The main anthropometric indices used for children are weight-for-height, height-for-age and weight-for-age. Body Mass Index is the main index used for adults and is defined as the weight (kilograms) divided by the square of height (meters). The World Health Organization (WHO) had adopted data from the National Center for Health Statistics (NCHS), United State of America, as a reference standard, since many studies have shown that, the growth of normal healthy and adequately nourished children almost always approximates these reference values irrespective of racial or genetic background. Previously, anthropometric data for children were reported as percentages of the reference median but nowadays they are presented as SD-Z-scores, based on standard deviations (SDs) above or below the median reference value for a person of a given age (WHO, 1995). At any age, the level of median minus 2 SDs is usually taken, as the threshold below which under nutrition exists.

2.9.1 Weight for height

The weight-for-height index is used for children in relation to accepted reference values. In the acutely undernourished children, those who have inadequate dietary intakes or an acute infection within recent weeks, decline in body weight is relatively rapid, but height remains unchanged in adults and changes very slowly in children. Weight for height is a measure of wasting and is the index used in nutritional emergencies as well as for long-term situations of undernutrition, such as famine. In children, weight-for-height data can be used to assess undernutrition without accurate knowledge of the individual's age (Gibson, 1990).

2.9.2 Height for age

The height-for-age indicator is used for assessing chronic under nutrition in children. Prolonged undernutrition causes retardation of growth in both height and weight to a roughly comparable degree. Impaired height gain relative to age is called stunting. Height gain is most affected by long-term environmental and socio-economic factors; hence, it reflects general socio-economic conditions (Simon, 1999).

2.9.3 Weight for age

The proportion of children under five years of age in many developing countries who are below the weight-for-age reference median -2SDs ranges from 10 to 100 percent, with an average of around 20 to 30 percent. The weight-for-age indicator is often easier to determine and is thus more readily available than weight for height or height for age. It can, however, be more difficult to interpret because it is a consequence of either acute or chronic under nutrition or, indeed, of both (Gibson, 1990).

Present procedures for using the above indicators and for evaluating results obtained from them were prescribed following a major survey in Egypt (USAID, 1978), which involved 8600 children from the whole country. According to the usual criteria for malnutrition, 47% were considered malnourished using weight for age, 22% using height for age, but only 3% when using weight for height. Body-size adaptation to poor nutrition and poor health was recognized, and many arguments developed as to how many children were really malnourished and who were those at most risk. Currently we usually assess malnutrition by using all three criteria and base action accordingly. Highest priorities for action are given for acute malnutrition, i.e., those with weight for height that is more than 2 SDs below the median. If 5 - 10% of the population group is below this level, the degree of wasting may be described as moderate; if the proportion is more than 10%, the situation is generally considered severe. In developing countries, widespread chronic stunting is common. The proportion of individuals below the median (minus 2SDs) is often in the range of 20% to 60%, with an average near 100%. Populations in which height for age of 25% to 40% of the children under five is 2 SDs below the median are commonly considered to be moderately affected while those with more than 40% are considered severely affected (Gibson, 1990).

2.9.4 Body-mass index

Body-mass index, or BMI, provides a measure of body mass ranging from thin to obese. Adults with low BMI generally have lower work capacity and limited social activity. They also generally have lower incomes and more sickness, and women have a higher proportion of low body weight babies (FAO, 1994; James, 1994). Table 2 shows the classification of nutritional status based on BMI cut-off points.

Table 2: Proposed classification of body mass index (Kg/m2)

Nutritional status	BMI
Chronic energy deficiency, Grade 3	<16.0
Chronic energy deficiency, Grade 2	16.0-16.9
Chronic energy deficiency, Grade I	17.0-18.4
Normal	18.5-24.9

Overweight	25.0-29.9
Obese	30.0-40.0
Morbidly obese	>40.0

FAO (1994).

2.10 Factors that influence iodine content in salt

Iodization may take place inside the country at the main production or packing sites, or outside the country by importing salt, which has already been iodized. Salt is iodized by the addition of fixed amounts of potassium iodate, or sodium iodide as either a dry solid or an aqueous solution, at the point of production.

Potassium iodate is recommended in preference to Sodium iodide because it is much more stable (Aghini-Lombardi *et al.*, 1997; WHO, 1993). The stability of iodine in salt and levels of iodization are crucial to the national health authorities and salt producers, as they have implications for programme effectiveness, safety, and cost. The actual availability of iodine from iodized salt at the consumer level can vary over a wide range due to variability in the amount of iodine added during the iodization process; uneven distribution of iodine in the iodized salt within batches and individual bags; the extent of loss of iodine due to salt impurities, packaging, and environmental conditions during storage and distribution; and loss of iodine due to food processing, and pre-cooking processes at the households.

2.11 Effect of relative humidity on stability of iodine in salt

Salt is extracted from a variety of sources, and the degree of purity depends on the source, extraction, and purification methods used. As a result, salt that is available for iodization may contain sodium chloride but also carbonate and sulphates, insoluble matter, and moisture. Physically, salt may be sold as large, crude crystals or as refined, pure, dry powder (Diosady, 1997).

Losses of iodine in food are common and many studies have been done to investigate the stability of iodine in salt. Experiments conducted by Diosady (1997) indicated that, high humidity reduces stability, while the use of a good vapour barrier, which prevents the penetration of moisture and the evaporation of iodine, clearly improved the stability of iodine in iodized salt. A study by Diosady *et al*. (1996) showed that, storage of salt samples at 100% relative humidity resulted in the greatest iodine loss. Even under moist, tropical conditions, it is unlikely that the relative humidity would remain at this extreme level for a long period. However, within bags exposed to sunlight, or in storage facilities heated by the sun, the high humidity will be retained, once moisture is absorbed into the bag contents, and temperatures may readily rise to over 60 ºC. Only one month of exposure to 40 ºC and 100% relative humidity resulted in loss of 25% of iodine added to salt stored in high-density polyethylene bags. In all cases, the samples stored at 60% relative humidity lost iodine at a lower rate than those stored in saturated air (100% relative humidity). After six months, storage losses at 60% relative humidity ranged from 0% to 20%, which is lower than might be expected and losses after 12 months averaged approximately 40%. At high humidity, the losses were more dramatic. Iodine losses over six months of storage ranged up to 100%, indicating that within the 12-month trial period, essentially all of the iodine added to the sample disappeared from high-density polyethylene bags, which were effectively open to the atmosphere. Also, Mosha *et al*. (2004) reported that, for the salt samples packaged in low-density polyethylene film bags, iodine losses ranged from 1.5 to 3.3 percent, while those packaged in high-density polyethylene woven bags the losses ranged from 1.1 to 6.7 percent. The moisture content ranges for the salt samples packed in closed containers were 0.29 - 5.78%, 1.25 - 5.42% (low density polyethylene bag), in high-density polyethylene woven bags were 4.07 - 9.69% while in jute bags were 4.12 - 10.02% (Mosha *et al*., 2004). Based on the above observations, closed containers and low density polyethylene film bags were the most suitable packaging materials for retaining iodine in table salt.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The study was conducted in two goiter endemic regions of Tanzania namely, Morogoro and Iringa. In Morogoro, the study was conducted at Berega village (Gairo ward) in Kilosa district while in Iringa region the study was conducted at Rungemba, Kitelewasi and Kinyanambo villages in Mufindi district.

3.1.1 Morogoro region

Morogoro region is situated about 200 km West of Dar es Salaam. The population of Morogoro is 1 759 809 and that of Kilosa district is 488 191 according to Tanzania 2002 Population Census (Tanzania Bureau of Statistics, 2002). Administratively, Morogoro region is divided into six districts and it occupies a total land area of 72 939 km^2. Annual rainfall ranges from 600 mm in lowlands to 1200 mm in the highland plateaus. The mean annual temperatures vary with altitude from 18°C to 30°C. Major food crops include maize, paddy/rice, sorghum, cassava, beans, peas, banana, sweet potatoes and millets. Cash crops include sisal, vegetables (tomatoes). The region is also endowed with a variety of fruits and vegetables and livestock such as sheep, goats and chicken. Fishery activities are also carried out in major rivers such as Kilombero and Wami. Major ethnic groups include Luguru, Kaguru, Ndamba and Pogoro.

Kilosa district is located at 6.84 °S – 36.99 °E. The district has a population of 488 191. The annual rainfall is between 600 - 1200 mm per year and temperatures range between is 25 - 35 °C. The main cash crops cultivated in Kilosa are maize, sweet potatoes, fruits and vegetables. Animals kept are goats, cattle, pigs and chicken. Among the health facilities in the district include Berega hospital located in Berega village.

3.1.2 Iringa region

Iringa region lies in the Southern Highlands of mainland Tanzania. It has a total land area of 58 936 km^2. It has seven administrative districts, namely Mufindi, Makete, Njombe, Ludewa, Kilolo, Iringa Rural and Iringa Urban. The population of Iringa region is 1 495 333 and that of Mufindi district is 282 071 according to Tanzania 2002 Population Census (Bureau of Statistics, 2002). The main ethnic groups are Hehe, Bena, Kinga, Maasai, Barbeig and Pangwa. The region has several climatic conditions dividing the region into three agro-ecological zones; the highlands, midlands, and lowlands zones. Temperatures range from 15 to 25 °C. In all the zones, rainfall regime is from November through May. Food crops grown include maize, sorghum, paddy/rice, wheat, beans, cassava, Irish potatoes, sweet potatoes, groundnuts, fruits and vegetables. Cash crops grown include tea, coffee, pyrethrum, sunflower, tobacco and cotton. Livestock kept include cattle, goats, sheep and donkeys.

Mufindi district is located at 7.77 °S - 35.69 °E, with a population of 282 071 and land area of 56 864 km^2. Food crops cultivated in Mufindi include maize, peas, sweet potatoes, Irish potatoes and vegetables. Cash crops include tea, maize, and peas. The major health facility available in the district is Mufindi district hospital.

3.2 Research design

The study was cross sectional whereby data were collected only once.

3.3 Sampling frame/population

3.3.1 Study population

The target study population included all school aged children aged 6 - 17 years, normal women of reproductive age 15 - 45 years, pregnant and lactating women. Exclusion criteria: All children in the selected age groups 6 - 17 years, who were lactating. All children in the selected age group 6 - 17 years, who were ill, mentally retarded and/or HIV positive, were excluded from the study. Likewise, normal, pregnant and lactating women who were insane, mentally unstable, ill or HIV positive were excluded from the study.

3.3.2 Sampling technique/procedure

Purposive, multistage and cluster sampling techniques were used to identify the regions, districts and villages that were involved in a larger national iodine intervention program (Iringa Nutrition Programme) more than 20 years ago. School registers were obtained from the respective district education officers. By using simple random procedures the representative schools were selected from the districts. Likewise, representative students were selected from the selected schools by using random numbers. A roaster of normal, pregnant and lactating women were obtained from the representative villages obtained from the district records. Representative women were randomly selected from the village roasters to participate in the study.

3.3.3 Sample size

The sample size was determined according to 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. The size of the sample was calculated from the formula:

$$n = Z \cdot (1 - p) \cdot {}^{Deff}\!/_{d} 2 \cdot \mathrm{p}$$

Where n= sample size, Z=1.96 for a confidence limit of 95%, p=expected prevalence of iodine deficiency disorders, D eff = sampling (multistage cluster) effect ($2 \leq D\ eff \leq 4$) and d= relative precision.

Calculation

Relative precision (d) = 30%

Cluster/strata effect (D eff) = 3%

Prevalence (P) = 23% (ICCIDD, 2001a)

Confidence limit (Z) = 1.96

Therefore $n = 1.96^2 . (1- 0.23).3 / 0.3^2 . 0.23$

n= 429

Therefore, the sample size was 429

3.4 Data collection

3.4.1 Construction of a questionnaire

A questionnaire was prepared to obtain information about women age, marital status, education level; awareness on dietary sources of iodine, iodine deficiency disorders and the use of iodized salt. The questionnaire was divided into four sections. Section A- solicited information about personal data, section B solicited information about sources of dietary iodine, section C solicited information about iodine deficiency disorders and section D solicited information about salt consumption.

3.4.1.2 Pre-testing the questionnaire

The questionnaire was pre-tested at Tanangozi village in Mufindi district. Tanangozi village had similar characteristics with the study villages but information from the pre-testing was not included in the main study. Pretesting helped to make some corrections in the questionnaire.

3.4.1.3 Administration of the questionnaire

Two enumerators were deployed for the study. Two-day training was conducted to teach the enumerators on how to ask questions, take anthropometric measurements and collect urine and salt samples. A face-to-face interview was conducted in the selected households. Household visits were conducted during the morning and evening hours when women were available at home. School visits were made in the mid-morning when students were on recess.

3.4.1.4 Measurement of weight

Body weight was measured by using SECA electronic bathroom weighting scale (0 - 150 kg) (SECA-Germany), which was placed on a flat surface. The scale placed on flat surface was adjusted to zero before taking measurements. Subjects were weighed bare feet with only light dresses. Unnecessary materials in the pockets such as mobile phones or wrist watches were removed during measurements. While taking measurements a person stood in upright position at the centre of the balance with the feet placed in a v-shape. Measurements were taken three times and the average was taken as the body weight. The weight was recorded to the nearest 0.1kg.

3.4.1.5 Measurement of height

Height was measured by using portable harpenden stadiometer (Holtain Ltd, UK). Subjects were asked to stand bare feet on a flat surface; the feet were placed together in the centre against the wall. The eyes of the subjects looked straight forward and the line of sight was in level with the ground/surface. Shoulders were in levels, hands pointed vertically downwards against the body, head, shoulder blades and buttocks touched against the wall. When these conditions were met, measurement was recorded. Measurement was taken three times and the average was taken as height. Height was recorded to the nearest 0.5cm.

3.4.1.6 Salt and urine samples collection

A small amount of salt (≈ 5g) was collected from each household. The sample was packed in airtight plastic bag. The brand name (whenever available), texture and physical appearance were recorded. Each subject was provided with a sterile sample bottle to put in urine sample. Whenever the urine or salt samples could not be available immediately, the sample was collected by the enumerator on the next day. Both salt and urine samples in airtight containers were stored in cool boxes prior to transportation to the Department of Food Science and Nutrition, Tanzania Food and Nutrition Centre, where further analyses were conducted.

3.5.1 Analysis of iodine in urine

Iodine concentration in urine samples was determined by the method of WHO/UNICEF/ICCIDD (1993) as revised by WHO (2001). Two hundred mL of urine were digested with one mL of 0.1M of ammonium persulfite to liberate free iodine. The free iodine formed catalyzed the reduction of Ceric Ammonium Sulfate (yellow) to cerous form (colourless). The change in color was measured at 420 nm using a spectrophotometer (Spectronic 21, Bousch and Lomb, Penn Yan, New York, USA). A standard curve constructed by plotting log absorbance at (420nm) versus the standard iodine concentrations was used to quantify the iodine concentrations in the urine samples (WHO, 2001).

3.5.2 Analysis of iodine in salt

Iodine concentration in salt samples was determined by iodometric titration involving digestion of iodized salt with sulphuric acid in the 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).

3.6 Data analysis

3.6.1 Analysis of respondents' awareness

Data collected by using the questionnaire were coded, and analyzed using Statistical Package for Social Sciences (SPSS) whereby descriptive statistics such as frequencies, percentages and median were obtained.

3.6.2 Analysis of respondents' nutritional status

EPI INFO Program Version 6 was used for determining weight for height, weight for age and height for age indices. Nutritional status of women was determined using BMI (kg/m^2) (WHO, 2004).

3.7 Ethical clearance

Permission was obtained from the Ministry of Health, Regional and District Authorities to conduct the study in the identified villages. Parents/guardians of the school children participating in the study and the pregnant, lactating and normal women involved in the study signed a consent form to affirm their willingness to participate in the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-economic and Demographic Characteristics of Respondents

4.1.1 Main occupation

Table 3 data show that, 72.2% (n = 109) of respondents from Kinyanambo, 80.4% (n = 107) from Kitelewasi, 85.9% (n = 107) from Rungemba and 76.6% (n = 107) from Berega village were farmers. Likewise, 14.8% (n = 108), 9.3% (n=107), 4.7 % (n = 107) and 5.6% (n = 107) of respondents from Kinyanambo, Kitelewasi, Rungemba.

Table 3: Socio-economic and demographic characteristics of women in the surveyed households

Berega village, respectively were businesswomen. The remaining percent was civil

Characteristics	Kinyanambo		Kitelewasi		Rungemba		Berega		Overall	
	No.	%	No.	%	No	%	No	%	No	%
Occupation										
Business women	16	14.6	10	9.3	5	4.7	6	5.6	36	8.4
Farmers	79	72.2	86	80.4	92	85.9	82	76.6	339	79.1
Civil services	13	12.2	11	10.3	10	9.3	19	17.8	53	12.4
Age (years)										
Under 19	46	42.6	32	29.9	53	49.5	36	33.6	167	38.9
20-34	44	40.7	55	51.4	46	42	55	51.4	200	46.6
Above 35	18	16.7	20	18.7	8	7.5	16	14.9	62	14.5
Physiological state										
Pregnant	18	16.7	15	14	15	14	6	5.6	54	12.6
Lactating	47	43.3	42	39.3	15	14	83	77.6	187	43.6
Normal	43	40	50	46.7	77	72	18	16.8	187	43.6
Marital status										
Single	24	22.2	4	3.7	15	14	12	11.2	55	12.8
Married	68	63.3	88	82.2	76	71	79	73.8	311	72.5
Widowed	7	6.7	2	1.9	1	0.9	10	9.3	20	4.7
Divorced	9	7.8	13	12.3	15	14	6	5.6	43	10
Head of household										
Male	70	64.8	84	78.5	83	77.6	69	64.5	306	71.3
Female	38	35.2	23	21.5	24	22.4	38	35.5	123	28.7

servants. Low or inadequate food consumption and consequent poor nutritional status may be the result of a variety of causes, often operating in combination, but the key determinants of food consumption are food availability (whether from local production or other sources) and people's access to that food (i.e. their capacity to produce or purchase). Therefore, obtaining a steady flow of food from an inherently irregular production and stable income are important in terms of food security, so as to ensure adequate nutrients consumption in the households (Simon, 1999). Most of the women in the surveyed households (78.6***%***) were involved in farming, which was essential for supplying the families with food.

4.1.2 Age of respondents

Table 3 indicated that, respondents with age under 19 years were 42.6% (n = 108) in Kinyanambo, 29.9% (n = 107) in Kitelewasi, 49.5% (n = 107) in Rungemba and 33.6% (n = 107) in Berega village. Results also showed that, 40.7% (n = 108) of respondents from Kinyanambo, 51.4% (n = 107) from Kitelewasi, 42% (n = 107) from Rungemba and 51.4% (n = 107) from Berega were at the age of 20-34 years, while 16.7% (n = 108) from Kinyanambo, 18.7% (n = 107) from Kitelewasi, 7.5% (n = 107) from Rungemba and 14.9% (n = 107) from Berega were above 35 years of age. Iodine deficiency disorders appear in all ages of life depending on iodine status of the individual, because the earlier the zenith of goitre prevalence appears in life the more severe iodine deficiency the population is exposed to (Nills *et al.*, 2002). Therefore age is an indicator that shows to what extent the individual is exposure to the risk of iodine deficiency.

4.1.3 Physiological state

Table 3 showed that, 16.7% (n = 108) of respondents from Kinyanambo, 14% (n = 107) from Kitelewasi, 14 %(n = 107) from Rungemba and 5.6% (n = 107) of respondents from Berega were pregnant women, while 43.3 (n = 108), 39.3 (n =

107), 14 (n = 107) and 77.6 percent (n = 107) of respondents from Kinyanambo, Kitelewasi, Rungemba and Berega villages, respectively, were lactating women. The remaining proportion of the respondents 40 % (n = 108), 46.7% (107), 72 %(n = 107), and 16.8% (n = 107) in Kinyanambo, Kitelewasi, Rungemba and Berega villages, respectively were physiologically normal. Iodine intake and status is affected during pregnancy and lactation periods due to increased demand of thyroid hormone. During pregnancy rise in Thyroxine-binding globulins and tri-iodothyronine hormone lead to decreased iodine for the maternal thyroid function, associated with increased renal clearance and transport to the feto-plancenta complex during the late phase of gestation (Glinoer, 1990). During lactation, iodine is concentrated in the mammary gland for excretion in breast milk. Hence using urinary iodine concentration to estimate iodine status may lead to an underestimation due to increased iodine demand (ICCIDD, 2007).

4.1.4 Head of the household

Results of the study indicated that, majority of the households in Kinyanambo (65.6%, n = 108), Kitelewasi (78.5%, n = 107), Rungemba (77.6%, n = 107), and Berega (64.5%, n = 107) were headed by males. In male headed households, large portions of food are usually saved to men and boys while women and girls usually get smaller portions. This kind of behavior was common in the surveyed households that reduce food availability and inadequate food consumption among households members hence lack of iodine. When food is not adequate, women and girls become more susceptible to iodine deficiency. In male headed households, males were the bread winners and were responsible for ensuring food was available at the households. Whenever both parents are available, such households tended to be more food secure, compared to single parent, female headed households.

4.1.5 Marital status

Table 3 showed that, 63.3%, 82.2%, 71% and 73.8% of respondents in Kinyanambo, Kitelewasi, Rungemba and Berega villages, respectively, were married while 22.2% (n = 108), 3.7% (n = 107), 14% (n = 107), and 11.2% (n = 107), of respondents in Kinyanambo, Kitelewasi, Rungemba and Berega villages respectively, were singles. About 6.7% (n = 108), 1.9% (n = 107), 0.9% (n = 107), and 9.3% (n = 107), in Kinyanambo, Kitelewasi, Rungemba and Berega village respectively, were divorced. Marital status has some impact on iodine intake, because both parents make efforts to ensure food supply to the family members. Families with both parents tend to be more food secure.

4.2.1 Urinary iodine concentration in schoolchildren

Table 4 data showed that, the median urinary iodine concentration of schoolboys (7 -8 years) in Kitelewasi village was 101.2 μg/L, whereby six schoolboys aged 9-10 years had urinary iodine concentration in the range 50 - 99 μg/L, three schoolboys (9-10 years) had urinary iodine concentration in the range 100 - 200 μg/L (adequate iodine concentration). Results revealed that, 10 schoolgirls (9 - 10 years) had adequate iodine concentration range of 100 - 200 μg/L, while eight schoolgirls (9-10 years) had mild (51 - 99 μg/L) iodine deficiency and one schoolgirl had severe iodine deficiency (< 20 μg/L). Median urinary iodine for schoolboys in Rungemba village was 79 μg/L and for schoolgirls was 107.7 μg/L (Table 4). Results showed that, in Rungemba one schoolboy aged 7-8 years had severe iodine deficiency (< 20 μg/L), four schoolboys (7 - 8years) had moderate iodine deficiency and six schoolboys (7 - 8 years) had mild (51 - 99 μg/L) iodine deficiency. Result also showed that, three schoolboys (9 - 10 years) had severe iodine deficiency, eight schoolboys (9 - 10 years) had moderate iodine deficiency and six schoolboys (9 - 10 years) had mild iodine deficiency, while six schoolboys (9 - 10 years) had optimal urinary iodine concentration of 100 - 200 μg/L. Two schoolboys (9 - 10 years) and six schoolboys had urinary iodine concentrations in the range of 201 - 300 μg/L and more than 300 μg/L, respectively. Result indicated further that, the median urinary iodine concentration for schoolgirls in Rungemba village was 107.7 μg/L. One schoolgirl (7-8 years) had severe iodine deficiency, seven schoolgirls (7 - 8 years) had mild iodine deficiency (50 - 99 μg/L), six schoolgirls (7 - 8 years) had optimal urinary iodine concentration in the range of 100-200 μg/L while one schoolgirl (7 - 8 years) and three schoolgirls (9 - 10 years) had excessive iodine intake in the range 201 - 300 μg/L and above 300 μg/L, respectively.

Table 4 also showed that, five schoolboys (7 - 8 years) and two schoolboys (9 - 10 years) in Kinyanambo village had urinary iodine concentration in the range 50 - 99 µg/L, 10 schoolboys (9 - 10years) had urinary iodine concentration in the range of 100-200 µg/L, six schoolboys (9 - 10 years) had excessive urinary iodine concentrations in the range 201 - 300 µg/L and 11 schoolboys (9 - 10 years) had urinary iodine concentration in the range above 300 µg/L.

Table 4: Urinary iodine concentration (µg/L) in samples collected from school

Village/Groups	Median	<20	20-49	50-99	100-200	201-300	>300
Kitelewasi							
Boy (years) 7-8	101.2	0	0	1	1	0	0
Boy (years) 9-10		0	1	6	3	2	5
Girls (years) 7-8	84.8	0	1	6	0	0	2
Girls (years) 9-10		1	6	8	10	0	2
Rungemba							
Boy (years) 7-8	79.0	1	4	6	2	0	0
Boy (years) 9-10		3	8	6	6	2	6
Girls (years) 7-8	107.7	1	1	7	6	1	0
Girls (years) 9-10		2	1	1	6	1	3
Kinyanambo							
Boy (years) 7-8	232.4	0	0	5	2	1	6
Boy (years) 9-10		0	2	2	10	6	11
Girls (years) 7-8	120.7	0	0	4	6	2	6
Girls (years) 9-10		1	0	4	6	1	11
Berega							
Boy (years) 7-8	111.7	0	1	2	0	2	1
Boy (years) 9-10		1	6	8	10	2	4
Girls (years) 7-8	109.5	0	2	4	1	0	1
Girls (years) 9-10		0	1	4	5	2	2
Overall							
Boys (years) 7-8	106.5	1	5	14	5	3	7
Boy (years) 9-10		4	16	22	29	12	26
Girls (years) 7-8	96.3	1	4	21	13	3	9
Girls (years) 9-10		4	7	17	27	4	18

Schoolgirls in Kinyanambo had median urinary iodine concentration of 120.7 µg/L. Table 4 results showed that, four, six, two and six schoolgirls aged 7 - 8 years in Kinyanambo had urinary iodine concentrations in the range of 51 - 99, 100 - 200, 201 - 300 and >300 µg/L, respectively. Results also revealed that, four schoolgirls aged 7 - 8 years had urinary iodine concentration of 51 - 99 μg/L (mild iodine deficiency) while one schoolgirl had urinary iodine concentration of less than 20 μg/L (severe iodine deficiency). The results indicated that, median iodine concentration of schoolboys (7 - 8, 9 - 10 years old) in Berega village was 111.7 μg/L (Table 4). One schoolboy aged 7 - 8 years, and six schoolboys (9 - 10 years) had urinary iodine concentration in the range of 20 - 49 μg/L (moderate iodine deficiency). Two schoolboys (7 - 8years) and six schoolboys (9 - 10 years) had urinary iodine concentration in the range of 50 - 99 μg/L (mild iodine deficiency) while one schoolboy (7 - 8 years) had urinary iodine concentration below 20 μg/L (severe iodine deficiency). Table 4 data revealed further that, 10 schoolboys (9 - 10 years) had adequate urinary iodine concentration (100 - 200 μg/L), two schoolboys (7 - 8 years) and two others (9 - 10 years) had excessive urinary iodine concentration in the range (201 - 300 μg/L). Also, one schoolboy aged 7 - 8 years and four others aged 9 - 10 years had excessive urinary iodine concentration of more than 300 μg/L.

Results indicated that, two schoolgirl (7 - 8 years), one schoolgirls (9 - 10 years) and four schoolgirls (9 - 10 years) had urinary iodine concentration in the range of 20 - 49 μg/L (moderate iodine deficiency) while four schoolgirls (7 - 8 years) and four others aged 7 - 8 had urinary iodine concentration in the range of 50 - 99 μg/L (mild iodine deficiency). One schoolgirl (7 - 8 years) and five others (9 - 10 years) in Berega had urinary iodine concentration in the range 100-200 μg/L (optimal iodine concentration). Overall, results of the study showed that, 50 schoolboys and 60 schoolgirls had mildly iodine deficiency with urinary iodine concentration in the range of 50 - 99 μg/L. Also five schoolboys and nine schoolgirls in the surveyed villages had severe iodine deficiency with urinary iodine concentration below 20 µg/L. Result showed further that, 27 schoolboys and 12 schoolgirls had moderate iodine deficiency (urinary iodine concentration in the range of 20 - 49 µg/L) while 39 schoolboys and 40 schoolgirls had optimal urinary iodine concentration (urinary iodine concentration in the range of 100 - 200 µg/L). More than 18 schoolboys and 19 schoolgirls in the surveyed villages had excessive urinary iodine concentration >200 µg/L.

According to WHO (2001) and ICCIDD (2001b), urinary iodine concentrations are classified as follows: concentrations < 20 µg/L indicate severe iodine deficiency, 20 - 49 µg/L indicate moderate iodine deficiency, 50 - 99 µg/L - mild iodine deficiency, 100 - 200 µg/L - optimal iodine intake, 201 - 300 µg/L - more than adequate, and >300 µg/L - excessive iodine intake with risk of adverse health consequences. The median urinary iodine concentrations for schoolboys and girls in this study were 106.5 µg/L and 96.3 µg/L, respectively. Previous study by Mosha *at el.* (2004) indicated that, the median urinary iodine for schoolboys and girls were 166 and 169 µg/L, respectively. In respect to the WHO (2001) and ICCIDD (2001b) recommendations, the schoolboys had optimal iodine status while schoolgirls had mild iodine deficiency.

4.2.2 Urinary iodine concentration in samples collected from pregnant, lactating and normal women

It was observed that, the median urinary iodine concentration for pregnant women in Rungemba village was 106.3 µg/L, and only one pregnant woman had urinary iodine concentration > 300 μg/L. The median urinary iodine concentration of lactating women in Rungemba village was 47.7 μg/L, and five lactating women had urinary iodine concentration in the lower range of < 20 μg/L, 14 lactating mothers had urinary iodine concentration in the range 20 - 50 μg/L, while six, three and six lactating women had urinary iodine concentrations in the range 51 - 99 μg/L, 100 - 200 μg/L and 201 - 300 μg/L, respectively. Table 5 summarizes the urinary iodine concentrations μg/L in urine samples collected from pregnant, lactating and normal women.

Table 5: Urinary iodine concentration (μg/L) in samples collected from pregnant, lactating and normal women

Village/Groups	Median	<20	20-50	51-99	100-200	201-300	>300
Rungemba							
Pregnant	106.3	1	0	0	1	0	1
Lactating	47.7	5	14	6	3	6	1
Normal	35.4	5	3	4	1	1	1
Kinyanambo							
Pregnant	399.4	0	0	1	1	0	3
Lactating	218.0	1	0	0	5	2	6
Normal	225.9	0	3	1	2	4	5
Kitelewasi							
Pregnant	79.9	0	0	3	0	0	1
Lactating	289.4	0	0	0	1	1	8
Normal	554.25	1	1	1	3	0	5
Berega							
Pregnant	37.15	0	1	1	1	0	3
Lactating	199.3	0	0	0	6	1	3
Normal	218.0	0	3	0	3	2	4
Overall							
Pregnant	155.7	1	1	5	3	0	8
Lactating	188.6	6	14	4	15	11	18
Normal	258.4	4	6	10	6	9	7

Table 5 data showed that, the median urinary iodine concentration for the normal women in Rungemba village was 35.4 μg/L. According to ICCIDD (2007), adequate median urinary iodine concentrations for pregnant, lactating and normal women are

150 - 249, > 100 and 100 - 200 µg/L, respectively. Also urinary iodine concentrations < 20 µg/L indicates severe iodine deficiency, 20 - 49 µg/L indicates moderate iodine deficiency and 50 - 99 µg/L indicates mild iodine deficiency and concentrations above 200 µg/L indicate excessive urinary iodine concentration in pregnant, lactating and normal women. One pregnant, five lactating and five normal women had severe iodine deficiency (< 20 µg/L). Fourteen lactating and three normal women in Rungemba village had moderate iodine deficiency (20 - 50 µg/L), while six lactating and four normal women had mild iodine deficiency (51 - 99 µg/L) (Table 5).

The median urinary iodine concentration for pregnant women in Kinyanambo village was 399.4 µg/L. Only three pregnant women had urinary iodine concentration in the range > 300 µg/L, while two others had urinary iodine concentration in the range 100 - 200 µg/L and 51 - 99 µg/L. Six lactating women out of 35 had urinary iodine concentration in the range >300 µg/L. Only two lactating women had urinary iodine concentration in the range of 200 - 300 µg/L, while five others had urinary iodine concentration in the range 100 - 200 µg/L. The median urinary iodine concentration was 218.4 µg/L and 225.9 µg/L for lactating and normal women, respectively (Table 5). Less than half of the normal women (5 out of 15) had urinary iodine concentration in the range > 300 µg/L. Only three normal women had urinary iodine concentration in the range 100 - 200 µg/L. The above data revealed that, no pregnant or normal woman had severe iodine deficiency in Kinyanambo village and only one lactating woman had severe iodine deficiency (< 20 µg/L). Three normal and one pregnant women had moderate (20 - 50 µg/L) and mild (51 - 99 µg/L) iodine deficiency, respectively.

Data for Kitelewasi village (Table 5) indicated that, the median urinary iodine concentration was 79.9, 289.4 and 554.25 µg/L for pregnant, lactating and normal women, respectively. Three pregnant women had urinary iodine concentration in the range of 51 - 99 µg/L (mild iodine deficiency), while one pregnant woman, eight lactating and five normal women had urinary iodine concentration > 300 µg/L (excessive iodine intake). Iodine status of women in Kitelewasi village was good, since the data showed that, only one normal woman had severe iodine deficiency (urinary iodine concentration < 20 µg/L) and no lactating or pregnant woman had severe iodine deficiency.

Women in Berega village had median urinary iodine concentration of 237.15 µg/L for pregnant women, 199.3 µg/L for lactating women and 218 µg/L for the normal women. Six lactating and three normal women had urinary iodine concentration in the range 100 - 200 µg/L (optimal iodine intake) while three pregnant, three lactating and four normal women had urinary iodine concentrations above > 300 µg/L (excessive iodine intake). According to ICCIDD (2007), the recommended median urinary iodine concentrations for pregnant, lactating and normal women are 150 - 249, ≥ 100 and 100 - 200 µg/L, respectively. Based on the above recommendations, the median urinary iodine concentrations of pregnant (106.3 µg/L), lactating (47.7 µg/L) and normal women (35.4 µg/L) in Rungemba village were below the recommended concentrations. Pregnant, lactating and normal women in Kinyanambo village had median urinary iodine concentrations above the recommended levels. In Kitelewasi and Berega villages urinary iodine concentrations for pregnant women was below the recommended concentration. Conversely, median urinary iodine concentration for lactating women was adequate while for the normal women the urinary iodine concentration was more than adequate. Overall, the median urinary iodine concentrations in all villages showed that, pregnant and lactating women had adequate iodine status while normal women had more than the recommended urinary iodine concentrations.

4.2.3 Iodine concentration in salt samples

It was observed that, 96.6% (n = 29) of the salt samples from Kitelewasi village had iodine concentration ranging between 20 - 50 ppm, while other samples (3.4%, n = 29) had iodine concentration in the range 51 - 75 ppm. About (n = 26) 69.2% of salt samples from Rungemba village had iodine concentration in the range 20 - 50 ppm, while 23.1, 3.8 and 3.8 percent had iodine concentration below 20 ppm, 76 - 100 ppm and above 100 ppm, respectively (Table 6).

Table 6: Iodine concentrations (ppm) in the salt samples collected from the surveyed households

Names of villages	Iodine concentration (ppm)									
	<20		20-50		51-75		76-100		>100	
	No.	%	No.	%	No.	%	No.	%	No.	%
Kitelewasi	0	0.0	28	96.6	1	3.4	0	0.0	0	0.0
Kinyanambo	5	16.7	23	76.7	1	3.3	1	3.3	0	0.0
Rungemba	6	23.1	18	69.2	0	0.0	1	3.8	1	3.8
Berega	8	16	42	84.0	0	0.0	0	0.0	0	0.0
Total (n = 135)	**21**	**15.6**	**109**	**80.7**	**2**	**1.5**	**2**	**1.5**	**1**	**0.7**

Likewise, 76.7% (n = 30) of salt samples from Kinyanambo village had iodine concentration in the range of 20 - 50 ppm, while 16.7, 3.3 and 3.3 percent of the salt samples had iodine concentration in the range < 20, 51 - 75 and 76 - 100 ppm, respectively. None of the salt samples had iodine concentration above 100 ppm. About 84% (n = 50) of the salt samples from Berega village had iodine concentration in the range of 20 - 50 ppm, while 16% had iodine concentration level below 20 ppm. According to WHO/UNICEF/ICCIDD (1996) recommendations, iodine concentration in salt at the point of consumption should be within the range of 20 - 40 ppm in order to provide the required 150 ppm per adult per day. The study revealed that, most of salt samples (109 out of 135) had the recommended amounts of iodine concentrations. These findings were in line with the recommendation by URT (1995) and Jeje *et al*. (1997), who stated that, iodine concentration in salt at the consumption level, should not be less than 30 ppm in order to provide the required optimal amount of iodine for good health.

4.3 Respondents' knowledge on dietary iodine, socio-economic and cultural practices affecting iodine intake

4.3.1 Respondents' understanding of the term iodized salt

The data showed that, majority 74.2% (n = 429) of the respondents did not understand iodized salt. They purchased salt without caring whether it was iodized or not. More than 25% (n = 429) of the respondent had correct knowledge about iodized salt. For those who had knowledge about iodized salt, most of them got the information from public health meetings and health campaigns, maternal reproductive and child health clinics, mass media (radios and TV), and/ or primary schools.

Table 7: Respondents' knowledge on dietary iodine, socio-economic and cultural practices affecting iodine intake

Knowledge/practice	No of respondents	Percentage (%)
Understand iodine		
Yes	111	25.8
No	318	74.2
Foods rich in iodine		
Meat	5	1.1
Fish	81	18.9
Iodized salt	313	73.1
Don't know	30	6.9
Effects of inadequate intake of iodine		
Goiter	107	25
Don't know	322	75
Addition of salt in cooking		
At the beginning of cooking	317	73.9
During cooking	95	22.2
At the end of cooking	13	3.1
At the table	3	0.8
Places where salt was purchased		
Small retail shops	416	96.9
Local markets	13	3.1
Salts labelled "iodized salt		
Yes	95	22.2
No	316	73.6
Didn't check	18	4.2

4.3.2 Respondents' knowledge on dietary sources of iodine

It was revealed in the study that, only 1.1% (n = 429) of the respondents had the knowledge that meat contains iodine, 18.9% (n = 429) of respondents were aware that sea fish was a good dietary source of iodine and only 6.9% (n = 429) knew that iodized salt was the dietary source of iodine. Use of salt (especially iodized salt) is the most effective and affordable method to prevent iodine deficiency disorders. Although most foods do not contain appreciable amount of iodine, one teaspoon of iodized salt consumed daily is more than sufficient to satisfy physiological requirements for this nutrient. Other dietary sources of iodine include drinking water, seafood (clams, lobster, oysters, sardines and ocean fish) and dairy products. The iodine content of fruits and vegetables is dependent upon soil content. About 73.1% (n = 429) of respondents did not know foods that were rich sources of iodine.

4.3.3 Respondents' knowledge on adverse effects of inadequate iodine intake

This study revealed that, most of the respondents were not listening to radio or watching TV and did not take seriously the issue of iodized salt (Table 7). Data also showed that, 75% (n = 429) of the respondents did not know the adverse effects of inadequate intake of iodine, while 25% (n = 429) of the same have heard about the goitre through radio/TV programmes and/or have seen them in their localities or in other villages around the district.

4.4 Socio-cultural practices affecting Iodine intake

4.4.1 Time of salt addition in food

The study showed disparity in time of adding salt to food during cooking. Table 7 shows the different times during cooking salt was added to the food-at the beginning, during cooking, at the end of cooking or at the table. It was revealed that, 73.9% (n = 429) of the surveyed households added salt at the beginning of cooking, 22.2% (n = 429) of households added salt during cooking, 3.1% (n = 429) of the respondents added salt at the end of cooking, while 0.8% (n = 429) of the respondents added salt at the table. Exposure of iodine to heat and moisture has been reported to enhance degradation of iodine (Diosady *et al*., 1997; WHO, 2001). Under normal cooking conditions, about 20% of iodine in salt is lost during cooking, before the food is consumed (WHO/UNICEF/ICCIDD, 1996). To ensure maximum iodine retention, it is recommended that, salt should be added to foods at the table, after the cooking process is finished. A study by Uzo-uwain (1994) revealed that, salt handling practices such as exposure of iodized salt to heat, light and moisture reduced or depleted its iodine content, which could result into iodine deficiency. The practice of adding salt in food at the beginning of cooking was therefore not appropriate because iodine in salt was exposed to excessive heating that could lead to iodine degradation and eventual loss.

4.4.2 Salt purchasing

Table 7 data showed that, 96.9% (n = 429) of respondents purchased salt from small shops at their villages, while 3.1% (n = 429) of respondents purchased salt from local markets. Purchasing salt from some places has an effect on iodine content of the salt, because the salt could be improperly stored for a long time (more than 6 months) before it is sold out. A study by Mosha *et al*. (2004) revealed that, salt samples lost iodine after being stored for more than six months. Therefore, the place where salt is purchased may have an affect the content of iodine in the salt. Also, salt sold in open markets was more likely to lack iodine (Mosha *et al*., 2004).

4.4.2.2 Salt packaging and labelling

It was revealed in the study that, only 22.2% (n = 429) of the respondents were aware that the salt they purchased was iodized because they checked the labels, while 4.2% (n = 429) of the respondents did not check if the purchased salt was iodized or not. According to the Tanzania Food Control Act (URT, 1995) and the Tanzania Bureau of Standards specifications for edible common salt (TZS 132:1996E) (TBS, 1996) all salt sold in Tanzania must be properly labeled to reveal its brand, iodization, and manufacturer's name and address. Therefore inability of respondents to check or to know if they were purchasing iodized salt made them vulnerable to cheating and unable to identify the salt brands or even identify the manufacture's name and address.

4.4.3 Factors affecting consumers' choice of salt during purchasing

It was revealed in the study that, majority of 39.2% (n = 429) the respondents were influenced by the prices of salt during purchasing. The prices ranged from 100 to 250 TShs per packet of salt weighing 50 - 100 g. The prices made some respondents to prefer buying and using coarse salt than fine salt because coarse salt was sold at lower prices compared to the fine salt. As shown in Table 8, 35.8% (n = 429) of the respondents made choices according to what was available in the market. Taste of salt influenced about 8.3% (n = 429) of respondents' choices in purchasing salt. For example, some of the respondents reported that coarse salt had better taste than fine salt, although coarse salt had some difficulties in dissolving in food during cooking. Also, 16.7% (n = 429) of the respondents purchased salt because they were used to do so and no any factor influenced their choices of any brand. Majority (85.8%, n = 429) of the respondents preferred fine salt to coarse salt (14.2%, n = 429). The reasons advanced varied from one type of salt to another. However, price offered, salt availability; quantity and cooking attributes (palatability) were identified as reasons for their selection. It was observed that, majority of the respondents (37.2%, n = 429) were influenced by the convenience of getting the salt at the nearby purchasing places. About 18.6% (n = 429) of the respondents were influenced by the taste and the low selling price especially those who liked to purchase coarse salt. Also, 13.1% (n = 429) of the respondents made their choices based on salt taste while 10.6% and 7.8% (n = 429) of the respondents made their choices based on whether the salt was iodized and convenience to obtain the iodized salt, respectively.

4.4.3.2 Mode of purchasing salt

Table 8 data show that, 91.9 % (n = 429) of the respondents purchased salt from polyethylene packages of 50 to 100g sold at the retail shop and local markets while 8.1% (n = 429) of the respondents purchased salt measured in cups. Majority of the respondents (92.2%, n = 429) stored salt in airtight plastic containers, while 1.4% and 6.4% (n = 429) of the respondents stored salt in tin containers and in polyethylene packages, respectively. Of those who stored salt in containers, 90% (n = 429) stored the salt in containers with tight lids while 10% (n = 429) stored the salt in containers with no lids. UNICEF (1993) pointed out poor storage methods as one of the factors which enhance loss of iodine in salt. Poor storage of salt exposes iodine to light or heat, which fragments the iodized salt and cause iodine to evaporate (UNICEF, 1993).

Table 8: Factors affecting consumers' choice of salt during purchasing and methods of salt packaging, handling and storage at the surveyed households

	No. of respondents	Percentage
Factors affecting consumers' salt choices during purchasing		
Price	168	39.2
Availability	154	35.8
Taste	35	8.3
Tradition	72	16.7
Salt packaging, handling and storage		
Salt packaging when purchasing		
Open containers	35	8.1
Polyethylene packages	394	91.9
Types of storage devices		
Plastics containers	396	92.2
Tin containers	6	1.4
Polyethylene packages	27	6.4
Containers with covers (lids)	386	90
With no covers (lids)	43	10
Form of Salt preferred		
Fine salt	368	85.8
Coarse salt	219	14.2
Reasons		
Good taste	56	13.1
Iodized	45	10.6
Taste and low price	80	18.6
Easy to get	160	37.2
Easy and low price	55	12.8

Easy to get and had iodine	33	7.8

4.4.1 Nutritional status of the studied school children

Table 9: Distribution of the WA, WH and HA Z-scores for the school children involved in the survey

Village/Social group	Normal		Mild		Moderate		Severe		P-value	Standard deviation
	No.	%	No.	%	No.	%	No.	%		
WAZ										
Kinyanambo										
Boys	23	51.1	11	24.4	11	24.4	0	0	0.01	0.88
Girls	16	40	12	30	10	25	2	5		
Kitelewasi										
Boys	5	26..3	9	47.4	3	15.8	2	10.5	0.01	0.21
Girls	11	30.6	15	41.7	7	19.4	3	8.3		
Rungemba										
Boys	9	20.9	21	48.8	11	25.6	2	4.7	0.01	0.80
Girls	6	20.7	12	41.4	10	34.5	1	3.4		
Berega										
Boys	7	18.9	16	43.2	10	27	4	10.8	0.01	0.89
Girls	8	36.4	7	31.8	7	31.8	0	0		
WHZ										
Kinyanambo										
Boys	43	95.6	2	4.4	0	0.0	0	0.0	0.01	0.21
Girls	38	95	2	5	0	0.0	0	0.0		
Kitelewasi										
Boys	19	100	0	0.0	0	0.0	0	0.0	0.01	0.00
Girls	36	100	0	0.0	0	0.0	0	0.0		
Rungemba										
Boys	42	95.3	1	2.3	0	0.0	0	0.0	0.01	0.79
Girls	27	93.1	2	6.8	0	0.0	0	0.0		
Berega										
Boys	36	97.3	1	2.7	0	0.0	0	0.0	0.01	0.13
Girls	22	100	0	0.0	0	0.0	0	0.0		
HAZ										
Kinyanambo										
Boys	12	26.7	14	31.1	13	28.9	6	13.3	0.01	0.11
Girls	14	35	8	20	12	30	6	15		
Kitelewasi										

Boys	4	21.1	3	15.8	7	36.8	5	26.3	0.01	1.09
Girls	9	25	9	25	11	30.6	7	19.4		
Rungemba										
Boys	0	0	10	23.3	22	51.2	11	26.3	0.01	0.6
Girls	0	0	4	13.8	19	65.5	6	20.7		
Berega										
Boys	5	13.5	7	18.9	12	32.4	13	35.1	0.01	0.97
Girls	1	4.5	8	36.4	9	40.9	4	18.2		
Overall										
WAZ										
Boy	44	30.9	57	40.1	35	24.6	8	4.2	0.01	
Girls	41	32.3	46	36.2	34	26.8	6	4.7		
WHZ										
Boys	140	97.3	4	2.7	0	0.0	0	0.0	0.01	
Girls	123	96.9	4	3.4	0	0.0	0	0.0		
HAZ										
Boys	21	14.6	34	23.6	54	37.5	35	24.3	0.01	
Girls	24	18.9	29	22.8	41	32.3	23	18.1		

4.4.1.1 Weight for Age Z-Score (WAZ)

Results of the study indicated that, 51.1% (n = 45) of schoolboys and 40% (n = 40) of schoolgirls in Kinyanambo village had normal weight for their age. Also, 24.4% (n = 45) of schoolboys and 30% (n = 40) of schoolgirls in Kinyanambo village were mildly underweight, while 24.4% (n = 45) and 25% (n = 40) of schoolboys and schoolgirls respectively in Kinyanambo village were moderately underweight. In Kitelewasi village 26.3% (n = 19) of schoolboys and 30.6% (n=36) of schoolgirls had normal weight for their ages. Overall, 47.4% (n = 19) of schoolboys and 41.7% (n = 36) of schoolgirls in Kitelewasi village were mildly underweight, 15.8% (n = 19) of schoolboys and 19.4% (n = 36) of schoolgirls were moderately underweight while 10.5% (n = 19) of schoolboys and 8.3% (n = 36) of schoolgirls in Kitelewasi were severely underweight (Table 9).

Results also indicated that, 20.9% (n = 44) of schoolboys and 20.7% (n = 29) of schoolgirls in Rungemba village had normal weight for their ages. About 48% (n = 44) of schoolboys and 41.4% (n = 29) of schoolgirls were mildly underweight, while 25.6% (n = 44) and 4.7% (n = 44) of schoolboys and 35.5% (n = 29) and 3.4% (n = 29) of schoolgirls were moderately and severely underweight, respectively. In Berega village, 18.9% (n = 37) of the schoolboys and 36.4% (n = 22) of schoolgirls had normal weight for their ages. About 43%, 27% and 10.8% (n = 37) of the schoolboys were mildly, moderately and severely underweight; while 31.8%, 31.8% (n = 22) of the schoolgirls in Berega village were mildly and moderately underweight, respectively. There were no schoolgirls who were severely underweight in Berega village. Children with normal weights for their respective ages indicate that, there was no acute or chronic undernutrition.

4.4.1.2 Weight for height Z-score (WHZ)

Table 9 data indicate that, majority (95.6%; n = 45) of schoolboys and 95% (n = 40) of schoolgirls in Kinyanambo and also, 100% (n = 19) of the schoolboys and of schoolgirls (n = 36) in Kitelewasi village were not wasted. Likewise, 95.3% (n = 44) of schoolboys and 93.1% (n = 29) of schoolgirls in Rungemba village were not wasted. A similar situation was found in Berega village. Normal weight for age indicates that, children were not acutely undernourished, which is associated with adequate food consumption and lack of acute infections.

4.4.1.3 Height for Age Z-Score (HAZ)

Table 9 data showed that, 26.7% (n = 45) of schoolboys and 35% (n = 40) of schoolgirls in Kinyanambo village were normal. It was also revealed that, 31.1%, 28.9% and 13.3% (n = 45) of schoolboys and 20%, 30% and 15% (n = 40) of schoolgirls were mildly, moderately and severely stunted, respectively. Results revealed further that, 21.1% (n = 19) of schoolboys and 25% (n = 36) of schoolgirls in Kitelewasi village had normal heights for their respective ages while 15.8% (n = 19) of schoolboys and 25% (n = 36) of schoolgirls were mildly stunted. Also, 36.8% (n = 19) of schoolboys and 30.6% (n = 36) of schoolgirls were moderately stunted while 26.3% (n = 19) of schoolboys and 19.4% (n = 36) of schoolgirls were severely stunted (Table 9). In Rungemba village, the data showed that 23.3% (n = 44) of schoolboys and 13.8% (n = 29) of schoolgirls were mildly stunted, 51.2% (n = 44) of schoolboys and 65.5% (n = 29) of schoolgirls were moderately stunted, while 26.3% (n = 44) of schoolboys and 20.7% (n = 29) of schoolgirls were severely stunted.

For Berega village, the data indicated that, 13.5% (n = 37) of schoolboys and 4.5% (n = 22) of schoolgirls had normal heights for their ages, 18.9% (n = 37) of schoolboys and 36.4% (n = 22) of schoolgirls were mildly stunted, 32.4% (n = 37) of schoolboys and 40.9% (n = 22) of schoolgirls were moderately stunted and 35.1% (n = 37) of schoolboys and 18.2% (n = 22) of schoolgirls were severely stunted.

Overall, this study indicated that, in the four villages surveyed, 30.9% (n =144) of schoolboys and 32.3% (n = 127) of schoolgirls had normal weights for their respective ages, while 40.1% (n = 144) of schoolboys and 36.2% (n = 127) of schoolgirls were mildly underweight. About 24% (n = 144) of schoolboys and 26.8%

(n = 127) of schoolgirls were moderately underweight, while 4.2% (n = 144) of schoolboys and 4.7% of schoolgirls were severely underweight. Results showed further that, majority 97.3% (n = 144) of schoolboys and 96.9% (n = 127) of schoolgirls in the surveyed villages had normal weights for their respective heights. Also, 14.6% (n = 144) of schoolboys and 18.9% (n = 127) of schoolgirls had normal heights for their respective ages, while 23.6% (n = 144) of schoolboys and 22.8% (n = 127) of schoolgirls were mildly stunted. It was further revealed that, 37.5% (n = 144) of schoolboys and 32.3% (n = 127) of schoolgirls were moderately stunted, while 24.3% (n = 144) of schoolboys and 18.1% (n = 127) of schoolgirls were severely stunted.

These results revealed that, schoolchildren in the surveyed villages had adequate food consumption and there was no record of acute infections in the recent weeks prior to the survey. Stunting usually results from chronic under-nutrition, resulting in retardation of linear growth, whereas wasting results from inadequate nutrition over a shorter period. Underweight encompasses both stunting and wasting (Laura *et al.* 2006). Iodine deficiency disorders have been associated with growth and developmental abnormalities such as stunting and wasting (Higdon, 2003).

4.4.2 Nutritional status for pregnant, lactating and normal women

Table 10 summarizes the distribution of BMI for pregnant, lactating and normal women in Kinyanambo, Kitelewasi, Rungemba and Berega villages. More than 40% (n = 139) of pregnant, 41% (n = 139) of lactating and 22.3% (n = 139) of normal women in the surveyed villages had BMI in the normal range (18.5 - 24.99). Results also showed that, 7.2% (n = 139), 12.9% (n = 139), 8.6% (n = 139) of pregnant, lactating and normal women, respectively, had BMI above normal range (25 - 29.99).

Table 10: Distribution of Body Mass Index (BMI) for pregnant, lactating and normal women

	18.5-24.99		25-29.99		≥ 30	
Village/group	No.	%	No	%	No.	%
Rungemba						
Pregnant	1	0.7	2	1.4	0	0.0
Lactating	29	20.9	7	5.0	0	0.0
Normal	11	7.9	3	2.1	0	0.0
Kitelewasi						
Pregnant	2	1.4	2	1.4	0	0.0
Lactating	6	4.3	3	2.1	0	0.0
Normal	8	5.7	3	2.1	0	0.0
Kinyanambo						
Pregnant	2	1.4	2	1.4	1	0.7
Lactating	13	9.4	6	4.3	1	0.7
Normal	7	5.0	1	0.7	1	0.7
Berega						
Pregnant	1	0.7	4	2.9	1	0.7
Lactating	9	6.5	2	1.4	0	0.0
Normal	5	3.6	5	3.6	1	0.7
Overall						
Pregnant (18)	6	4.3	10	7.2	2	1.4
Lactating (76)	57	41	18	12.9	1	0.7
Normal (45)	31	22.3	12	8.6	2	1.4

According to WHO (2004) BMI range 25 - 29.99 is classified as overweight. The study indicated that, 0.7% (n = 139), 1.4% (n = 139) and 1.4% (n = 139) of pregnant, lactating and normal women, respectively, were obese (BMI > 30). There is no recommendation BMI for pregnant women. BMI is only useful in pregnant prior to conception because it is used to determine the recommended weight gain during gestation.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

This study revealed that, iodine deficiency in schoolboys was not a health problem among schoolboys in the surveyed villages. Schoolboys had adequate intake of iodine with median urinary iodine concentration of 111.7 μg/L, however, schoolgirls had a mild iodine deficiency (96.3 μg/L). Pregnant, lactating and normal women had median urinary iodine concentration of 155.7, 188.6 and 258. 4 μg/L, respectively. According to ICCIDD (2007), adequate median urinary iodine concentrations for pregnant, lactating and normal women are 150 - 249, > 100 and 100-200 μg/L, respectively. These data suggested that, pregnant and lactating women had adequate iodine status based on the median urinary iodine concentrations (150 - 249 and 100 μg/L) while the normal women had excessive iodine intake (median urinary iodine concentration >200 μg/L).

Majority of respondents lacked knowledge on the proper time of adding salt to food during cooking. Iodine concentrations in salt samples collected from the households were within the acceptable levels. More than , 80.0% (n = 135) of the samples collected from the surveyed households had iodine concentrations above 20 ppm, which was the minimum amount of iodine concentration recommended in salt at consumption level. The study also revealed that, 30.9% (n = 144) of schoolboys and 32.3% (n = 127) of schoolgirls had normal weight for age, while only 4.2% (n = 144) of schoolboys and 4.7% (n = 127 of schoolgirls were severely underweight. Majority of schoolboys (97.3%, n = 144) and (96.9%, n = 127) of schoolgirls had normal weight for height. Further, 14.6% (n = 144) of schoolboys and 18.9% (n = 127) of schoolgirls had normal height for age and about 24% of schoolboys and 18% of schoolgirls were severely stunted. Furthermore, 41 % (n = 139) of lactating and 22.3% (n = 139) of normal women had BMI within the range (18.8 - 24.99) while more than 12% of lactating, and 8% of normal women were overweight. Based the urinary iodine concentrations, schoolboys, pregnant, lactating and normal women had good iodine status while schoolgirls had mild iodine deficiency. Most of respondents had no knowledge about iodized salt and iodine deficiency disorders, despite a strong nutrition education programme that was carried out in the study villages about 20 years ago. For sustainability of the nutrition education frequent education programmes must be planned.

5.2 Recommendations

On the basis of the above results, nutrition education on effects of iodine deficiency disorders, salt handling during storage and cooking, knowledge on iodized salt and iodine deficiency disorders are needed in the surveyed villages. Likewise, regular monitoring of iodine in representative subgroups of the population and quality control of iodine levels in salt at district and local levels is important to ensure that adequate iodine is reaching the people.

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APPENDIX

Appendix 1: QUESTIONNAIRE

QUESTIONNAIRE FOR PREGNANT, LACTATING AND NORMAL WOMEN ON AWERENESS OF DIETARY SOURCES OF IODINE, IODINE DEFICIENCY DISORDERS AND THE USE OF IODIZED SALT

Personal Data

1. Date of Interview………………….
2. Village……………………………….3. Ward …………………………….
4. Name of respondent ……………………………………………………
5. Age of respondent…………………………………………………………
6. Physiological state……………………………………………………

   1. Pregnant women 2. Lactating women

   3. Normal women
7. Type of Household

1 = Male headed 2. = Female headed

8. Marital status

1 = Single 2 = Married 3 = Widowed 4 = Divorced

9. Tribe ………………………………..

10. Main occupation

1= Self employed 2 = Farming 3 = Teacher = Nurses 5 = Business (specify)

11. What is the main source of household income?

1 = Sale of crops 2 = Sale of livestock 3 = Salary 4. Self employed (specify)

Sources of dietary iodine

12. What type of crops is grown?

………………………………………………

……………………………………………….

……………………………………………….

13. Are your living at what type of landscape?

1. Gentle slope 2. Steep slope 3. Plain

14. Do you understand the term iodine?

Yes… No…

15. If yes, what are sources of iodine in your food?

1. Meat 2. Fish 3. Iodized salt 4. Others (specify)

Iodine Deficiency Disorders

16. Do know the consequences of not taking adequate iodine?

1.Yes   2. No

17. If yes, list one consequence of not taking adequate iodine

……………………………………………

Salt Consumption

18. Do you use salt in your food?

1 = Yes   2 = No.

19. If yes, where do you get your salt?

1 From shop 2. From local market

3. Home made 4. Others (specify).

20. Which type of salt do you most commonly use in the household?

21. Which type of salt did your household use in the past 3 months?

1 = Iodated 2 = Non iodated 3 = Salt substitute

22. What factors affect your choice of salt during purchase?

1 = Price 2= Availability 3 = Taste 4 = Tradition 5 = others (specify).

23. What is mode of purchase of salt? In which form of package do you purchase from? 1 = Cups 2 = Packets 3 = Other

24. When do you add salt to food when cooking?

1 = At the beginning 2 = During cooking 3 = At the end of cooking

4 = at the table 5 = others (specify).

25. How do you store your salt in the household?

1 = Plastic container 2 = Tin container 3 = Paper 4 = Others (specify).

26. Does the container have a lid? 1. Yes   2. No

27. Salt condition 1 = Moist 2 = Dry

28. What type of salt do you prefer?

1 =Fine salt 2 = Coarse salt

29. Why do you prefer the type of salt you're specified before?

1……………….. 2…………………..

THANK YOU FOR COOPERATION