

**IODINE STATUS AND DIETARY HABITS AMONG PRIMARY
SCHOOL CHILDREN IN KINONDONI, TANZANIA**

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**A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of
Master's in Life Sciences of the Nelson Mandela African Institution Sciences and
Technology**

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ABSTRACT

Tanzania is one of the countries where excessive iodine intake has been reported; hence intervention and identification of possible causes is required. The present study assessed iodine status and determined the critical contributors to excessive iodine intake in school children from Kinondoni, Tanzania. A total of 322 pupils and 30 food vendors provided salt samples for iodine analysis. Urinary iodine concentration (UIC) was spectrophotometrically determined in 266 sub-sampled children using the ammonium-persulfate digestion method. Information on dietary habits was collected using the Food Frequency Questionnaire and 24 hours dietary recall. Anthropometric values were determined by measuring children's height and weight. Moreover, Knowledge, Attitude, and Practices study was done using a modified specific iodine deficiency-related questionnaire. Of the salt samples, 87% were adequately iodized with mean 53.94 ± 13.02 , indicating over iodization. The median UIC was 401 $\mu\text{g/L}$, signifying excessive iodine intake. Twelve percent were overweight or obese and only 46.6% of pupils and 53.3% of food vendors had good knowledge of iodized salt utilization. Discretionary salt use (67.3%), higher consumption of potato chips (53.5%) and fried cassava (59.0%) were associated with a higher risk of excessive iodine intake. Potato chips (Adjusted Odds Ratio [AOR] =9.04, 95% CI: 3.61-22.63) and fried cassava consumption for 4-7 days/week (AOR=11.08, 95% CI: 3.45-35.54) were significantly associated with excessive iodine intake. Discretionary salt intake significantly contributes to the high iodine status of schoolchildren in the study area. This effect can be reduced by public health campaigns to decrease salt consumption and improve salt iodation practices.

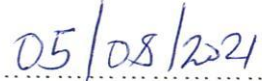
Keywords: iodine status; junk foods; children; urinary iodine concentration; salt iodization; salt intake

DECLARATION

I, Mario Sibamenya Venance do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.




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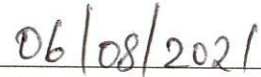


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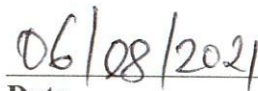
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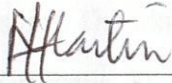
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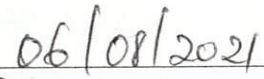
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CERTIFICATION

The undersigned certify that they have read the dissertation titled “Iodine status and dietary habits among primary school children, Kinondoni Tanzania” and recommended for examination in fulfillment of the requirements for the degree of Master’s in Life Sciences of the Nelson Mandela African Institution of Science and Technology.



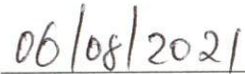
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DEDICATION

I dedicate this work to my beloved Wife, Saada Ramadhan, my Children Tarcisius and Theodosia, and my parents Mr. and Mrs. Venance Sibamenya. Above all, I thank the Almighty God for providing life, knowledge, and opportunities.

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LIST OF ABBREVIATIONS AND SYMBOLS

μ/L	Micrograms per liter
FFQ	Food Frequency Questionnaires
ICCIDD	International Council for Control of IDD
IDD	Iodine Deficiency Disorders
IGN	Iodine Global Network
IQ	Intelligence Quotient
KIO ₃	Potassium Iodate
KNCHREC	Northern Zone Health Research Ethics Committee
MUIC	Median Urinary Iodine Concentration
Ppp	Parts per million
SAC	School Aged Children
SD	Standard Deviation
T3	Triiodothyronine
T4	Thyroxin
TDHS	Tanzania Demographic and Health Survey
TDHS-MIS	Tanzania Demographic and Health Survey and Malaria Indicator Survey
TFNC	Tanzania Food and Nutrition Centre
Tg	Thyroglobulin
TGP	Total Goiter Prevalence (TGP)
TSH	Thyroid Stimulating Hormone
UIC	Urinary Iodine Concentration
UNICEF	United Nations Children's Fund
USI	Universal Salt Iodization
WHO	World Health Organization
WRA	Women of Reproductive Age

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

Iodine malnutrition is the leading cause of preventable brain damage. Iodine deficiency or excess affects the normal function of the thyroid gland (Katagiri *et al.*, 2017; Shen *et al.*, 2011; Zimmermann & Boelaert, 2015), as the thyroid gland is necessary for production of thyroid hormone needed for healthy brain development. Impaired function of these hormones in fetal life causes maternal hypothyroidism, which has cognitive and neurological consequences for the fetus, including severe and permanent brain damage (Hetzel, 1983). More than 285 million children and 2.7 billion people worldwide are at risk of iodine deficiency (Andersson *et al.*, 2012). World Health Organization (WHO) acknowledges iodine deficiency to be of public health importance (WHO, 2007b). In Tanzania, 41% of the population is at risk for iodine deficiency (Assey, 2009).

Iodine deficiency is caused mainly by either a low dietary iodine content or an absorption problem in the human body (Kennedy *et al.*, 2011). Iodized salt, seaweed, and seafood are the richest dietary sources of iodine (Haldimann *et al.*, 2005). Foods from animal origin, including milk and meat, can also be a significant iodine source if animals have grazed in iodine sufficient soils (Johnson *et al.*, 2003). Deficiency can also be caused by iodine malabsorption, as suggested by Kennedy *et al.* (2011), resulting from dietary goitrogens such as kale, cabbage, millet and cassava (Ershow *et al.*, 2018). Besides, iodine deficiency is also associated with low education level, poor socioeconomic status (Ba *et al.*, 2020; Mtumwa *et al.*, 2017), and poor salt iodation practices (Rana & Raghuvanshi, 2013).

World Health Organization recommends Universal Salt Iodization (USI) as a cheap approach in controlling IDD (WHO, 2007a). Overall, iodized salt household coverage globally has reached 88% (UNICEF, 2018). Iodized salt is a significant world dietary source, but its use varies widely in Africa. Only 8 African countries achieved the USI target from 2007 to 2011, and 11 countries had an iodine deficiency. Algeria, Sudan, Ethiopia, Mozambique, Angola, Ghana, and Morocco all have a tremendous iodine deficiency burden (Jooste *et al.*, 2013). In Tanzania, the practice of using adequately iodized salt shows a marked increase from 47% in 2010 to 61% in 2016 (Tanzania Demographic Health Survey - Malaria Indicator Survey

(TDHS-MIS), 2016). Irregularities in the iodized salt use are detected among residences and socioeconomic status, ranging from 96% in the wealthiest households to 69% in the most impoverished families (TDHS-MIS, 2016). Iodized salt utilization is above 90% in Arusha, Mbeya, and Dar es Salaam and lowest in Mtwara (27%), Lindi (23%), Simiyu (20%), and 14% in Kaskazini Pemba (TDHS-MIS, 2016).

In 2017, the Iodine Global Network (IGN) placed Tanzania among the countries displaying adequate iodine intake (IGN, 2017). However, previous and recent research showed a rise in the percentage of people with UICs above 300 µg/L (Assey *et al.*, 2009; Farebrother *et al.*, 2018; Zimmermann *et al.*, 2013), which is a cut-off point for excessive iodine intake (WHO, 2007a). Both insufficient and excessive iodine intakes have adverse health effects (Katagiri *et al.*, 2017; Zimmermann, 2009). Finding out contributory food groups for iodine among schoolchildren verifies the efficacy of iodine fortification programs and aids in developing recommendations that can be used to enhance iodine nutrition where required. On these rationales, this study was initiated to assess the iodine status and dietary habits along with the Knowledge Attitude and Practices (KAPs) on iodized salt utilization among primary school children in Kinondoni, Tanzania.

1.2 Statement of the Problem

For the last few decades, efforts to control iodine deficiencies have made tremendous progress across Africa (Jooste *et al.*, 2013). Sustainability surveys on iodine deficiency prevention have reported great progress in controlling and eliminating IDD in Tanzania since the 1990s (Assey *et al.*, 2009; Mosha *et al.*, 2004). However, sustaining this success remains a major challenge, as it requires close cooperation between partners at different levels and active monitoring of salt producers, food processors, and food handlers (Assey *et al.*, 2008, 2009; Jooste *et al.*, 2013).

In some countries where iodine fortification is compulsory, the incidence of excess iodine intake among schoolchildren has been increasing (Assey *et al.*, 2009; Duarte *et al.*, 2009; Seal *et al.*, 2006; Tamang *et al.*, 2019; Vargas-Uricoechea *et al.*, 2019; Zimmermann *et al.*, 2013). In Tanzania and elsewhere, this increase is significant and needs to be considered in iodine deficiency control programs. The Kenyan Government narrowed the mandatory iodine level for salt from 100 mg iodine/kg in 1978 to 30-50 mg iodine/kg salt in 2009 after elevated iodine status among school-age children (Bukania *et al.*, 2019; Mwaniki *et al.*, 2006). Brazil, also did

the same as Kenya in 2017 (Oliveira, 2017). Assey *et al.* (2009) reported 35% excessive iodine intake in SAC. Likewise, TDHS, (2015/16) reported excessive iodine intake in Dar es Salaam, Tanga, and Pwani of $\geq 300 \mu\text{g/L}$ above WHO recommendation. Marealle (2011) also found similar results in Arusha; similarly, Zimmermann *et al.* (2013) and Farebrother *et al.* (2018) in Dar es Salaam.

Most international organizations have paid little or no attention to excessive iodine intake; as much effort is emphasized to control low iodine intake (Laurberg *et al.*, 2001). Although it is known that excessive intake of iodine in normal healthy individuals does not produce adverse effects, the substantial increase in UICs among children triggered some concerns (Gao *et al.*, 2021; WHO, 2007a). Some studies reported possible causes, such as high iodine rich food like sea foods (Murray *et al.*, 2008), drinking water with high iodine level (Shen *et al.*, 2011) and high amount of KIO_3 added to salt (WHO, 2007). However, studies done by Eckhoff and Maage (1997) and Farebrother *et al.* (2018) in Tanzania do not show the significance of seafood and water to excess iodine intake. A study by Assey *et al.* (2009) recommended reducing the amount of potassium iodate added to salt during fortification as a solution. To do this, the WHO recommends iodine intake through processed foods and discretionary salt intake to be known (WHO, 2007a). However, neither the use of iodized salt during food processing nor the discretionary salt intake has been assessed. Consequently, this study was designed to assess iodine status and explore the contributing factors to daily iodine intake that could be useful in determining the safe level of iodine to be added to salt.

1.3 Rationale of the Study

The national iodine deficiency control program advocates the use of iodized salt in Tanzania to control IDD. However, recent research in Tanzania showed a rise in people with high iodine intake, especially among schoolchildren. This indicates possible inefficiency of the program in the country. Therefore, the current study aimed to examine the possible causes of high iodine intake to optimize the population's iodine nutritional status.

1.4 Objectives

1.4.1 General objective

To assess the iodine status and dietary habits among primary school children in Kinondoni Tanzania.

1.4.2 Specific Objectives

- (i) To assess the knowledge and practice on iodized salt utilization by school children and food vendors
- (ii) To assess the dietary intake of schoolchildren aged 6-14 years old
- (iii) To determine the level of urinary iodine concentration in school children aged 6-14 years old

1.5 Research Questions

- (i) What is the level of knowledge and practice on the use of iodized salt by school children and food vendors?
- (ii) What is the usual dietary intake of schoolchildren aged 6-14 years with regards to iodine intake?
- (iii) What is the level of urinary iodine concentration of school children aged 6-14 years old?

1.6 Significance of the Study

This study evaluated children's iodine status with their dietary habits in the Dar es Salaam region. Understanding dietary habits and discretionary salt use among school children can help determine the safe level of needed iodine fortification to meet daily iodine requirements. The study also provides information on the Knowledge, Attitude, and Practices (KAPs) of food vendors on iodized salt utilization. This study's findings provide baseline data on the KAPs of food vendors and school children on iodized salt utilization. They can guide assessment in other regions within the country.

1.7 Delineation of the Study

The study was limited to the investigation on possible causes for high iodine intake. It was based on assessing knowledge, attitude, and practices on iodized salt utilization and other iodine related issues toward attaining optimal iodine nutrition status of schoolchildren. Furthermore, the study involved the assessment of dietary intake and lifestyle behaviors of schoolchildren.

CHAPTER TWO

LITERATURE REVIEW

2.1 Occurrence of Iodine

2.1.1 Environmental Iodine

Iodine is one of the wealthiest micronutrients contained in seawater (Ito & Hirokawa, 2009). Despite oceans and seas occupying more than 70% of the earth's surface, these water bodies are the primary source of iodine in the animal and human food chains (Ito & Hirokawa, 2009). Originating from molten at the heart of the earth, the concentration and molecular composition of iodine differ within the sea levels by plant species, temperature salinity, and microorganisms (Ashworth, 2009; Ito & Hirokawa, 2009). Transfer of iodine from seawater into the food chain takes place across three main mechanisms. First, in the gaseous process, iodized seawater is evaporated and then precipitated over the ground, polluting soils, leaching into vegetation /crops and freshwater sources, second, saltwater fish, seaweed and algae, are used in the human /animal diet as food and or supplements and thirdly, iodine extraction from the water with small sedimentary, e.g., salt (Ashworth, 2009; Ito & Hirokawa, 2009). Human exposure to iodine occurs in the environment as gaseous (inhalation), liquid (drinking water), or solid form (ingestion of marine foods or iodine-enriched soil foods).

2.1.2 Foods Rich in Iodine

The main contributors to dietary iodine are from marine organisms. Saltwater fish, crustaceans, seaweed, and other aquatic organisms principally contain high iodine (Rasmussen *et al.*, 2009). Countries where these foods dominate as traditional cuisines typically have high dietary intakes of iodine (Rasmussen *et al.*, 2009; Zimmermann & Andersson, 2012b; Zimmermann *et al.*, 2005). For a healthy diet, iodine's contribution from food may differ between countries, particularly dairy/milk products, egg, and bread (Haldimann *et al.*, 2005; Rasmussen *et al.*, 2009). The application of iodophors during dairy farmers' sanitation practices has been demonstrated to determine the iodine content of dairy foods (Haldimann *et al.*, 2005).

If chickens are fed iodine-supplemented grain, the iodine content of the eggs will be enhanced. Alternatively, if food has been iodine fortified, the food's iodine content will be enhanced (Haldimann *et al.*, 2005; Van den Briel *et al.*, 2001; Zimmermann *et al.*, 2005). That is

generally known; dairy/milk products, seafood, eggs, and other cereals are the most common sources of iodine in foods (Haldimann *et al.*, 2005; Zimmermann *et al.*, 2005). However, the study done by Eckhoff and Maage (1997) in East Africa on iodine content in fish and other food products had lower iodine elements to meet the daily requirement. This study did not earmark junk foods that are usually consumed with iodized salt in most cases. Therefore, iodine intake through various foods, especially junk foods needs special attention for optimal iodine intake.

2.2 Iodine Absorption and Metabolism

The food iodine is consumed as iodide in the small intestines (Hurrell, 1997), and it is the principal source of the pool of extracellular iodine (Hurrell, 1997). It is introduced into the thyroid cell through an active transport mechanism via the sodium iodide (Na^+/I^-) symporter (Hurrell, 1997; Russell *et al.*, 2001) found in thyroid cells, placenta, uterus choroidal plexus, salivary glands, breast, rectal mucous tissue and lachrymal (Russell *et al.*, 2001). Thyroid hormone synthesis comprises five steps, namely trapping, iodination, iodization, pairing, and storage. The colloidal components are destroyed by endocytosis as thyroid hormones are secreted. Two hormones tri-iodothyronine (T3) and thyroxine (T4) are released into the blood after the proteolysis of thyroglobulin (Hurrell, 1997; Zimmermann, 2009). Two mechanisms control the secretion of thyroid hormones: thyroid-pituitary glandaxis and thyroid autoregulation between the organic iodine pool and the Na^+/I^- symporter's performance. Iodine deficiency contributes to cell proliferation by increased TSH-stimulation (Kimura *et al.*, 2001). The iodine-deficient thyroid tissue secretes growth factors that lead to follicle hyperplasia and fibroblast and vessel proliferation. Iodine deficiency induces a diffuse expansion of the thyroid gland and even degeneration and nodules after years. Iodine is given in single quantities only has temporary effects in healthy people because of the urinary removal compensation. However, suppose the regulatory mechanisms are defective. In that case, iodine-induced hyperthyroidism can follow because of increased absorption of iodine in organic compounds, because of its increased synthesis and increased release of thyroid hormones (Zimmermann, 2009).

2.2.1 Iodine Deficiency

When iodine deficiency exists, T3 and T4 are low in circulation that triggers a pituitary gland reaction to release more TSH (Hurrell, 1997; Zimmermann, 2009). Therefore, the epithelial

cell increases its sensitivity to NISs and its output of Tg to allow a higher absorption of iodide (Hurrell, 1997; Zimmermann, 2009). Consequently, thyroid cells and gland hyperplasia and hypertrophy occur, and a goiter could well develop (Hurrell, 1997). Especially when there is a chronic iodine deficiency of less than 50 µg/day, the thyroid enlargement occurs (Zimmermann, 2009). Thyroid gland hypofunction is found in situations where iodine deficiency persists uncorrected. The reduced production of the T3 hormone is of significance in neonates and infants because this is a significant growth hormone needed for neurocognitive and somatic growth (Delange, 2001; Hurrell, 1997) [Table 1]. In Tanzania, 25% of school children are iodine deficient (Assey *et al.*, 2009). Deficiency can also be caused by iodine malabsorption (Kennedy *et al.*, 2011), resulting from dietary goitrogens such as kale, cabbage, millet, and cassava (Ershow *et al.*, 2018).

2.2.2 High Iodine Intake

As reported elsewhere, the thyroid gland can tolerate up to 1000 folds above recommended dietary iodine intake in healthy people (Lewinski *et al.*, 2009). As predicted, an escalation in circulating hormones T3 and T4 are primarily detected where iodine is abundant and can lead to hyperthyroidism (Lewinski *et al.*, 2009). High iodine intake has been reported in some circumstances to stimulate T cells for immune response to produce Thyroid Peroxidase Antibodies (TPOAbs) and Thyroglobulin Antibody (TgAbs). This hampers iodine oxidation to iodide and iodine binding with Tg to form thyroid hormones. Under such cases, autoimmune thyroiditis is observed that may lead to the thyroid gland hypofunction (Lewinski *et al.*, 2009). Some of the effects of hypothyroidism are shown in Table 1. In Tanzania, 35% of school children have excess iodine intake (Assey *et al.*, 2009). Nevertheless, its cause and its subsequent intervention are still undocumented. The current study assessed the iodine content of frequently consumed junk foods among school- children.

Table 1: The Spectrum of Iodine Deficiency Disorders

Life stage	Effects
Fetus	Abortions
	Stillbirths
	Congenital anomalies
	Increased perinatal mortality
	Increased infant mortality
	Neurological cretinism: mental deficiency, deaf-mutism, spastic diplegia, and squint
	Myxedematous cretinism: mental deficiency and dwarfism
Neonate	Psychomotor defects
	Neonatal goiter
	Neonatal hypothyroidism
Child and Adolescent	Goiter
	Juvenile hypothyroidism
	Impaired mental function
	Retarded physical development
Adult	Goiter with its complications
	Hypothyroidism
	Impaired mental function

Table adapted from source: Iodine deficiency disorders (IDD) and their eradication (Hetzel, 1983).

2.2.3 Relationship between Iodine Intake and Thyroid Disease

Typically recognized as U-shaped, the relationship between iodine intake and thyroid disease has been well known, as thyroid impairment is observed in populations that are both iodine deficient and iodine excessive (Delange, 2001) [Fig. 1]. As a result of inadequate dietary intake of iodine, iodine-deficient peoples are likely to have symptoms of functional and developmental disabilities, including; endemic goiter, hypothyroidism, cretinism, and intellectual disability (Delange, 2001). More than 285 million children and 2.7 billion people worldwide are at risk of iodine deficiency (Andersson *et al.*, 2012).

In comparison, populations who overeat dietary iodine are more likely to develop autoimmune hypothyroidism (Haldimann *et al.*, 2005; Laurberg *et al.*, 2001). Examples are graves' disease, iodine-induced hyperthyroidism sporadic goiter, and some type of cancers (Lewinski *et al.*, 2009; Lind *et al.*, 1998). Lower intelligence quotients were observed in school children living in both iodine deficient and excess iodine (Field *et al.*, 2009; Liu *et al.*, 2009; Pandav & Anand, 1995). Tanzania has 25% to 35% of children with iodine deficient and high iodine intake,

respectively (Assey *et al.*, 2009). Examining what schoolchildren eat with daily iodine intake remained significant.

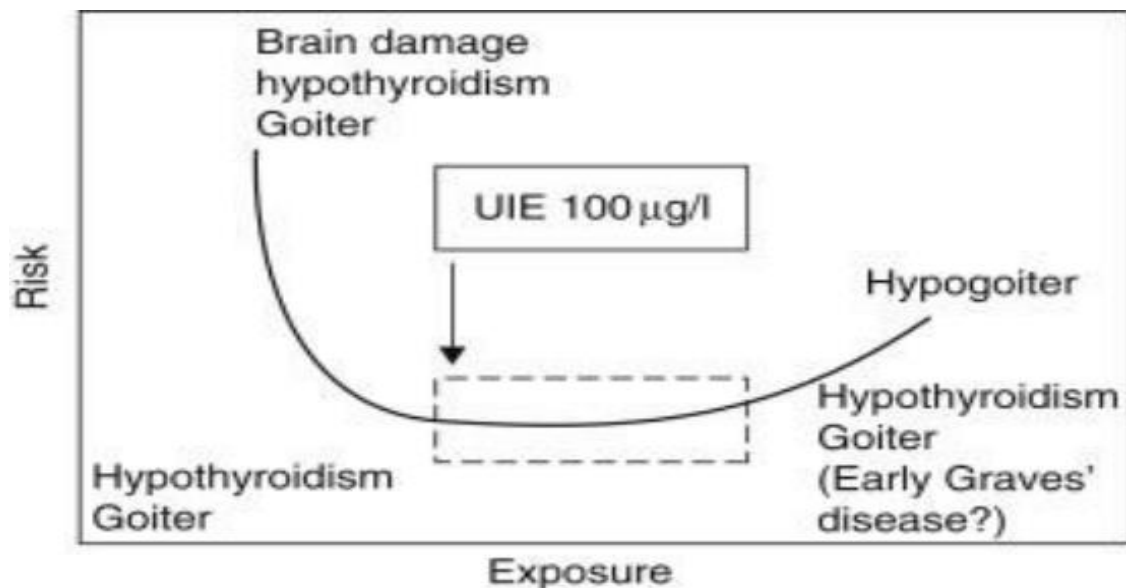


Figure 1: The u-shaped Curve Relationship between Iodine Intake and Thyroid Function (Laurberg *et al.*, 2009)

2.3 Methods for Monitoring Iodine Nutrition Status

2.3.1 Urine

More than 90% of dietary iodine is excreted through urine (Montenegro-Bethancourt *et al.*, 2015). The depiction of immediate exposure to iodine by the urinary analysis method is a viable predictor, as most iodine not absorbed by the body ultimately resides in the urine (WHO, 2007a). School children are the most preferred reference groups for iodine assessment in a population (WHO, 2007a). Urinary Iodine is typically expressed as urinary iodine excretion (UIE) from 24hr excretion, and iodine creatinine ratio and median urinary iodine concentration or UIC (ug/L) (Montenegro-Bethancourt *et al.*, 2015; Perrine *et al.*, 2014). The iodine status criterion for a population as per UIC is defined in Table 2.

Table 2: Assessment of Iodine Nutrition Based on Median UIC of School-Aged Children

Median UIC (ug/L)	Iodine Intake	Iodine status
< 20	Insufficient	Severe iodine deficiency
20-49	Insufficient	Moderate iodine deficiency
50-99	Insufficient	Mild iodine deficiency
100-199	Adequate	Optimal iodine nutrition
200-299	More than adequate	Likely to provide adequate intake for pregnant/lactating women, but may pose a slight risk in the general population.
> 300	Excessive	Risk of adverse health consequences (iodine-induced hyperthyroidism, autoimmune thyroid diseases)

Table adapted from source: Epidemiological parameters for the assessment of iodine status depending on median UIC of school-aged children (WHO, 2007a).

2.3.2 Thyroid Size

The volume of the thyroid gland responds inversely to changes in iodine intake. Increased thyroid size is a result of a history of poor iodine nutrition (Zimmermann, 2004). The thyroid size can be assessed either by neck inspection and palpation or by a novel technology called thyroid ultrasonography. Thyroid palpation is exceptionally useful when assessing goiter prevalence before any action to control IDD is implemented, but even less so when assessing impacts. It can be used as a long-term iodine exposure measure but does not indicate an acute iodine condition (Zimmermann, 2004). This method was not preferred for assessing iodine status because of its poor response to varying dietary iodine.

2.3.3 Assessment of Dietary Iodine Intake

Iodine nutrition assessment through the dietary intake is challenging. The challenges are exacerbated by the variation of the amount and type of food consumed daily, weekly, or seasonal (Serra-Majem *et al.*, 2009). The iodine content in foods is dynamic; it is determined by geographic location, rainfall, fertilizers, irrigations, sanitizers for the dairy industry, and type of grain feeds for livestock (Perrine *et al.*, 2014). The dietary iodine intake assessment is primarily assessed using the following nutrition evaluation tools; 24-hours dietary recall, food frequency questionnaire, and dietary records (Zimmermann & Andersson, 2012a).

All dietary assessment methods have bias (Serra-Majem *et al.*, 2009). However, FFQs are the most popular dietary evaluation method when measuring dietary mineral intake in epidemiological studies because of their relative ease of administration, the capability to capture long-term changes in diet and consumption patterns (Serra-Majem *et al.*, 2009; Zimmermann & Andersson, 2012a). The benefit of using FFQ in dietary evaluation is that it will show the regular dietary habits that participants will follow over a week, month, or year (Serra-Majem *et al.*, 2009; Zimmermann & Andersson, 2012a). Nevertheless, they are useful in classifying classes into high or low intakes and defining iodine's principal dietary sources (Rasmussen *et al.*, 2001). Due to these reasons, FFQ was used in collecting dietary iodine information in this study.

A- 24 hours dietary recall assesses short-term intakes and quantifies iodine foods consumed (Zimmermann & Andersson, 2012a). Although 24-hour recalls and repeated 24-hour dietary reports are best associated with nutritional reference markers, they are subject to the same recall bias as FFQs (Bourdoux, 1998). Dietary records are difficult to execute and tedious (Serra-Majem *et al.*, 2009; Zimmermann & Andersson, 2012a). Work from nearly 30 years ago showed that repeated data collection for many days was required to determine accurate intake measures for a single micronutrient (Basiotis *et al.*, 1987). For that reason, this method was not included in this study.

The minimum dietary intakes are 90 µg/day and 90-120 µg/day, respectively, for children aged 2-3 years and 8-10 years (WHO, 2007a) [Table 3]. Inferred from adult toxicity studies (Russell *et al.*, 2001; WHO, 2007a), the maximum limit for iodine consumption for this age groups is 200 µg/day and 300-600 µg/day, respectively (WHO, 2007a). Finding out the contributing iodine food groups within populations verifies the efficacy of iodine fortification programs and helps create guidelines that can be used to enhance iodine intake where appropriate.

Table 3: Recommended Dietary Allowances (RDAS) for Iodine and its Nutrition Status

Age	RDA	UIC (µg/L)		Iodine intake	Iodine status
0-6 months	110 µg	UIC for SAC UIC for Pregnant	< 100	insufficient	Iodine deficiency
7-12 months	130 µg		100-199	Adequate	Adequate Iodine nutrition
4-8 years	90 µg		200-299	above requirement	hyperthyroidism
9-13 years	120 µg		≥ 300	Excessive	hyperthyroidism
14-18 years	150 µg		< 150	insufficient	Iodine deficiency
19+ years	150 µg		150-249	Adequate	Adequate Iodine nutrition
Pregnancy	250 µg		150-249	above requirement	hyperthyroidism
			≥ 500	Excessive	hyperthyroidism

WHO, UNICEF, and ICCIDD (WHO, 2007a).

2.4 The Global Iodine Status

Urinary iodine concentrations reported in 150 countries found that 32 countries were iodine deficient; 71 countries were iodine 'adequate,' and 47 had more than adequate or 'excessive' iodine (WHO, 2007a; Zimmermann & Andersson, 2012b). The adverse consequences endured by populations with iodine deficiency have attracted significant attention worldwide (De Benoist *et al.*, 2004). In collaboration with UNICEF and Iodine Global Network (IGN), the WHO provides a clear framework for the proper implementation and monitoring of iodine prophylaxis programs (WHO, 2007a). These programs are country-specific and may include: iodized salt bread fortification, animal feed fortification of iodine or direct oral supplementation, and universal salt iodization (Andersson *et al.*, 2005). The prophylaxis programs adopted by many African countries, including Tanzania is Universal salt iodization.

2.5 Universal Salt Iodization and Current Iodine Status in Tanzania

Universal salt iodization and supplements are an extremely effective strategy for prevention and control of iodine deficiencies. In Tanzania, the IDD control program adopted USI as a long-term control measure, using Iodized Oil Capsules (IOC) as a startup and as a complement (Peterson *et al.*, 1999). The delivery of oral IOCs is a significant intervention in areas with IDDs and inadequate iodine salt coverage. Since 1986, IOC has been administered in districts where more than 10% of the school-aged children had goiter grade 1B or higher based on 1960 WHO goiter grading system (Peterson *et al.*, 1999). Twenty-seven districts were identified as endemic goiter districts. Total goiter prevalence is now dropped significantly from an unweighted average of 65.4 percent in the 1980s to 24.3 percent in 1999 (Assey *et al.*, 2007).

While there are still gaps between wealthy (96%) and low (69%) households, the percentage of households using adequate iodized salt (≥ 15 ppm) has risen from 47% in 2010 to 61% in 2016 (TDHS-MIS, 2016). However, the median UIC among population groups differs between studies and among regions: from <100 $\mu\text{g/L}$ to over 400 $\mu\text{g/L}$ for pregnant women. Furthermore, 25% of SAC have median UICs lower than 100 $\mu\text{g/L}$ and 35% over 300 $\mu\text{g/L}$ (Assey *et al.*, 2009).

Poor control of iodine fortification can lead to excessive iodine intake. Thirty-four countries, including Tanzania, reported excess iodine intake after USI (Andersson *et al.*, 2010). The tasks ahead lie in ensuring more significant coverage of sufficiently iodized salt, improving routine

monitoring of salt iodization, and the status of iodine in the population, along with simple measures for vulnerable population groups. Nevertheless, in Tanzania, there are limited and obsolete iodine nutrition data. The household iodized salt coverage and iodine status from various Tanzania studies are highlighted in Table 4.

Table 4: Overview of Studies on Iodized Salt Coverage and Iodine Status among Different Subgroups of the Tanzania Population

Author	Region/district	Population of Interest	Adequate iodized salt coverage	Assessment of Iodine status	Median UIC Outcome	Thyroid outcome
Assay <i>et al.</i> (2006)	27 endemic goiter districts	School children 6-18 years in 27 regions with previous history of iodine deficient, (n= 21 160)	83.3%	Thyroid ultrasound, UIC	235.0 µg/L	The overall unweighted mean visible and total goiter prevalence was 6.7% and 24.3%, respectively
Kulwa <i>et al.</i> (2006)	Ludewa district, Iringa	Parents/guardian and school children (n=150)	30%	UIC, FFQ	86.76 µg/L	Not Applicable (NA)
Assay <i>et al.</i> (2009)	21 districts	Schoolchildren aged 6 - 18 years (n=140,758)	83.6%	UIC	204 µg/L	Among all school children aged 6 - 18 years, the TGP was 6.9%
Assay <i>et al.</i> (2006b)	Unguja	Schoolchildren (n=11,967)	63.5%	UIC	185.7 µg/L	The mean total goiter prevalence was 21.3%
	Pemba		1%	UIC, palpation of the thyroid	53.4 µg/L	The mean total goiter prevalence was 32%
Farebrother (2018)	Dar es salaam	Urban Tanzania previously reporting iodine excess in children (n= 1390)2048	84%	UIC, TSH	192 µg/L for Lactating women and > 300 µg/L for SAC	In SAC, median DBS-Tg was 32 µg/L
Kulwa <i>et al.</i> (2008)	Arumeru district	Schoolchildren aged 8 - 10 years (n=100)	96%	UIC, FFQ	49.17 µg/L	NA

Author	Region/district	Population of Interest	Adequate iodized salt coverage	Assessment of Iodine status	Median UIC Outcome	Thyroid outcome
Mosha <i>et al.</i> (2010)	Southern Highlands Tanzania	Schoolchildren aged (n= 583)	99%	UIC, palpation of the thyroid	166 µg/L for boys and 171 µg/L for girls	Goiter prevalence was 7%, 0.5%, and 93% for Grade one, two, and zero, respectively
Ndaba (2018)	Southern rural Tanzania	Adolescent school girls (n= 128)	44.5%	UIC	192 µg/L	NA

2.5.1 Levels of Iodine added to Salt in Tanzania

At the processing point, salt is iodized by adding fixed quantities of potassium iodide (KI) or potassium iodate (KIO₃) either as an aqueous solution or a dry solid in a powder form. Tanzania uses iodate for iodine fortification due to its stability over iodide (Mannar *et al.*, 1995). The level of KIO₃ added to salt varies between countries and time (WHO, 2007a). Factors that cause these variations are salt packaging, transport, storage, cooking practices, and salt intake. It was initially mandated in Tanzania at 75-100 ppm in the early 1990s and has now been reduced to 20-80 ppm (TFDA, 2010). However, this range is relatively high as compared to 20-40 ppm recommended by WHO (WHO, 2007a).

The WHO recommends a range of 20-40 ppm by assuming 20 percent production loss, 20 percent food preparation loss and 10 g/day mean salt intake that provides 0.15 ppm person /day. It also emphasizes that in countries where iodized salt is used in processed foods like in Tanzania, the salt iodine levels should be lower than 20 ppm. However, data on dietary iodine from processed foods or junk foods in Tanzania is lacking to optimize the iodine levels. This study is thus providing further information on the contribution of junk foods to daily iodine intake.

2.6 Junk Foods and Iodine Intake

Junk food or fast foods are energy-dense food with a high amount of fat/sugar/salt content and inadequate fiber protein, mineral content, and vitamin. Junk foods and Fast foods are often used synonymously (Kaushik *et al.*, 2011). Examples include fried potatoes and cassava, crisps, processed meats, popcorn, kachori, cakes, cookies, chocolate, sugar-sweetened drinks, and takeaway foods like burgers and pizza, and pies. If these foods displace nutrient-dense foods, it may alter the daily iodine intake by either increasing or decreasing depending on whether iodized salt is used or not (Knowles *et al.*, 2017; Zimmermann, 2011).

In the lower and middle-income countries (LMICs), this food consumption is at peak (Popkin, 2015). Tanzania is also experiencing a “nutrition transition” characterized by increasing junk food consumption and a growing number of meals consumed away from home.

Economic growth, urbanization, and lifestyle changes are contributing factors (Keding, 2016; Maletnlema, 2002; Tschirley *et al.*, 2015), as people tend to opt for fast prepared food, which is junk food, due to the opportunity cost of time for food preparation. The comparison study

conducted in Tanzania by Cockx *et al.* (2017) on urbanization and dietary change indicated a significant shift from healthy staple food to junk foods.

Nevertheless, this nutrition transition affects not only the urban dwellers but also the rural people (Keding, 2016). In this shift, children and adolescents are disproportionately affected (Escalante de Cruz *et al.*, 2004; Tzioumis & Adair, 2014) as they spend most of their time away from home when attending schools and tuition classes (Rosenheck, 2008). They usually eat the food of their own choice when at school. Junk foods are usually addictive, highly advertised, readily available, good taste, low cost, and peer pressure hence attract more children over healthy foods (Kaushik *et al.*, 2011). Overconsumption of these foods has been linked with various health effects, such as increased body weight, hypertension, and other cardiovascular diseases (Tzioumis & Adair, 2014). However, little is known about how it alters the daily iodine intake among individuals.

2.7 Iodine Nutrition Knowledge and Practice of Iodized Salt Utilization

There is a clear connection between nutrition knowledge and dietary consumption and food choices, though it can be influenced by socio-cultural factors (Spronk *et al.*, 2014). Evidence from several studies found that the enhancement of public knowledge and public education on iodine among individuals is one of the most significant contributors to successful control of iodine deficiencies (Jooste *et al.*, 2005; Umenwanne & Akinyele, 2000). Consequently, the knowledge and practice on iodized salt utilization in Tanzania are limited. Estimating USI coverage and the knowledge and practices of proper utilization of iodized salt is usually done at the household level (Assey, 2009; Banumathi *et al.*, 2016; WHO, 2007b). Nevertheless, among other food handlers, such as the food vendors, are rarely explored. Furthermore, in many countries, especially in urban areas, food prepared or purchased outside the home is becoming an increasingly important diet (Bezerra *et al.*, 2013). Regular monitoring of the availability and proper iodized salt utilization in all food premises, including food vendors and processors, is an essential footstep in ensuring the elimination of IDD.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

Kinondoni is one of the five municipalities within the Dar es Salaam region. The municipal is administratively divided into two divisions, 20 wards, and 106 hamlets. It has a total population of 1 775 049 (914 247 females and 860 802 males), with 446 504 households and four people per household on average (Tanzania, 2015). The municipal has 121 primary schools and 72 secondary schools. It was purposively selected because of its high urban populations and reasonably high GDP per capita (URT, 2018). These factors are connected to increased access to junk foods (Tschirley *et al.*, 2015).

3.2 Study Design

The cross-sectional study design was employed to collect data.

3.2.1 Sample Size Calculation

A sample size of 367 was determined based on a previous prevalence of excessive iodine intake of 35% in school-aged children (Assey *et al.*, 2009). The estimate generated was based on a marginal error (d) of 5%, confidence interval of 95%, and 5% allowances for non-response (Muktar *et al.*, 2018).

$$n = \frac{z^2 pq}{d^2}$$

Where $q = (1-p)$, $z = 1.96$, $p = 0.35$, $q = 0.65$ and $d = 0.05$. Given $z = 1.96$, $p = 0.35$, $q = 0.65$ and $d = 0.05$, then 'n' was approximately 350. Including 5% of expected non-responding rate, the sample obtained was 367.

3.2.2 Recruitment of Schools

Schools were selected based on their socio economic status neighborhood that is high and low socioeconomic groups (HSGs and LSGs). Schools from LSGs were those located in Tandale, Magomeni and Kijitonyama, areas with socio-economic disadvantages and inequalities. HSGs were those located in Masaki peninsular. A socio-economic difference between these groups

provides an opportunity to investigate their influence on the status of iodine. Four schools from each stratum were randomly selected.

Moreover, each school was socioeconomically categorized based on the wards they belong. The municipal council provided the worth index of each ward. The list of schools was obtained from the primary school education department and divided as per socioeconomic groups. The list of food vendors was obtained from each school. Schools were chosen from each group using the probability proportionate to size technique (WHO, 2007a).

Before the school visit, ward education officers from the five selected wards were visited; the research's aim was explained to the ward education officers. The ward education officers introduced the researchers through letters to the head of schools. The study's aim and schedule of the fieldwork activities were discussed with teachers to ensure teachers' collaboration in recruiting children (Fig. 2).

3.2.3 Recruitment Procedures for Study Participants

The study participants were school children, both boys and girls aged between 6-14 years old, and food vendors. A-List of all pupils in the required age enrolled in the schools was identified from the attendance registry. The proportionate sampling approach was used to assign pupils in each class relative to the total number of pupils required per school. The estimated sample size ($n= 403$) [367 school children and 36 food vendors] was divided proportionately to the eight randomly selected schools (Fig. 2). For school, attendance registers were used as the sampling frame. Study participants were then enrolled randomly from standard III to VI on successive methodology until the needed sample size was obtained.

3.2.4 Inclusion and Exclusion Criteria

Inclusion criteria will be any age and any sex between 6-14 years; be in standard III to VI other classes will be excluded. For the food vendors, those who sell foods around school compounds for at least six months as listed in each school will be included. Boarding schools were excluded because, in most cases, the children depend entirely on school meals.

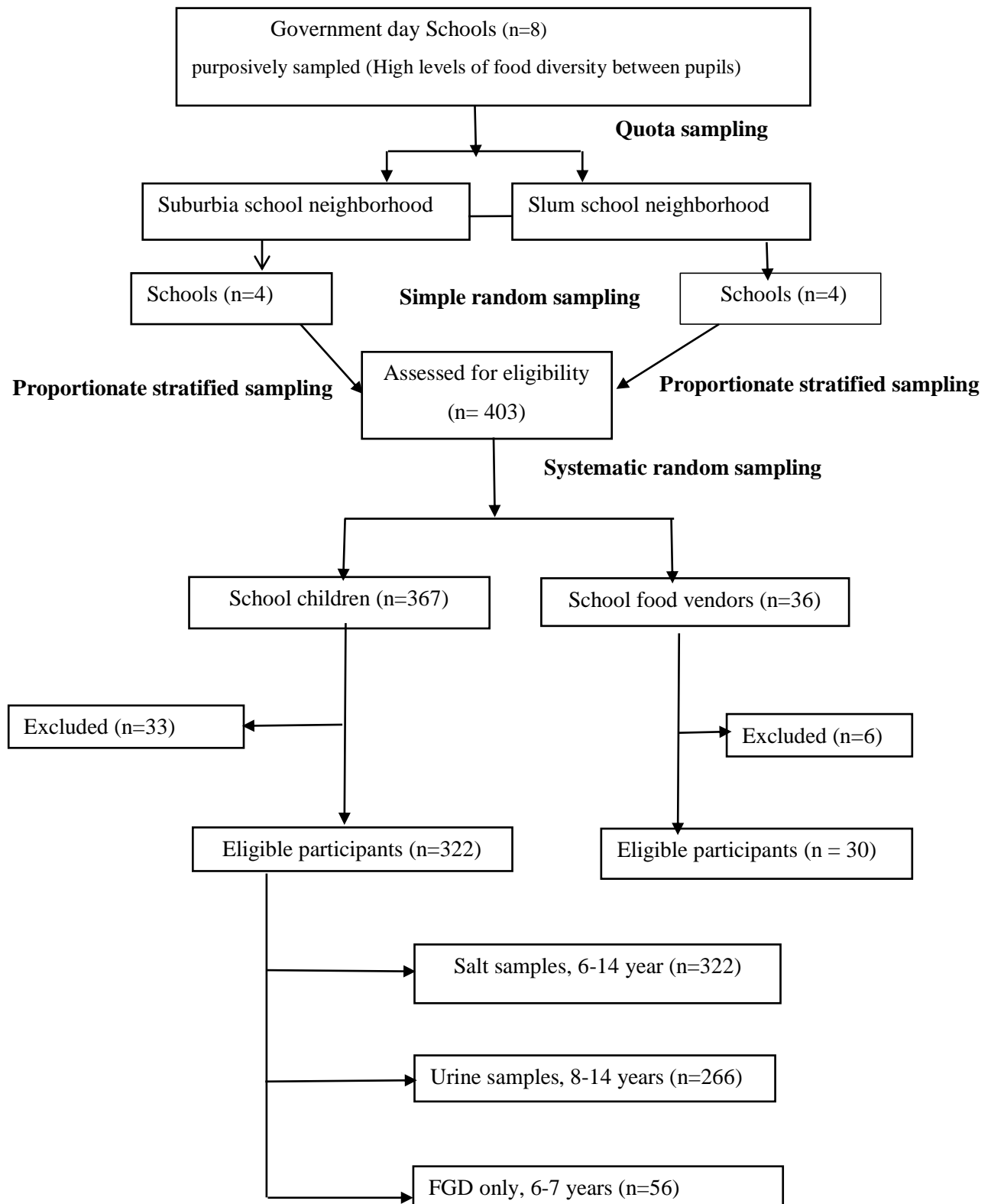


Figure 2: Recruitment of Schools and Participants Flow Diagram

3.2.5 Consent and Data Collection Procedures

The pupils were introduced to the study one day before data collection. Consent forms with all details about the study were given to pupils to take to their parents. A clean airtight plastic bag for the salt collection was provided to pupils. The pupil returned signed consent forms and salt samples on the following day. On the day of data collection, salt samples and parents' consent forms were collected and checked to see who consented. Children whose parents/legal guardians decline to consent to their child's participation in the study were excluded. Researchers explained participants' procedures for urine sample collection and anthropometric measurement. Each participating child was given a urine collection container for urine sample collection and given an identity number (ID). Finally, all salt samples and urine samples were cross-checked for IDs before being received for further analysis. Moreover, anthropometric measurements and demographic information were also collected.

Parents/legal guardians were given all detailed information about the study by their children one day before data collection, together with consent forms to complete if they agreed to their child's participation. The signed informed, voluntary, and written consent forms were collected from each of the participating children before commencing the data collection. Children whose parents/legal guardians decline to consent to their child's participation in the study were excluded. Each participating child assented verbally. All participants were notified of possible risks, benefits, anonymity, and the right to withdraw from the study.

3.3 Research Team

The research team consisted of five people; The Principal Investigator (PI), who is a Master's student at NM-AIST, three graduates who were interns at TFNC, and one Laboratory technician from TFNC. The PI liaised with the team, participated in all activities, and was fully involved in data collection and analysis. Research team members were fluent in Kiswahili and English language, which eased communication with study participants to get the intended responses. The research team was trained for two days on anthropometric measurements, dietary methods (24-hours dietary recall and Food Frequency Questionnaire), and sample (urine and salt) collection and handling. They were also oriented on how to test and interpret salt iodine content.

3.4 Ethical Clearance

The Kibong'oto Infectious Diseases Hospital- Nelson Mandela African Institution of Science and Technology- Centre for Educational Development in Health, Arusha (KIDH-NM-AIST-CEDHA) Health Research Ethics Committee (KNCHREC) approved this study (certificate number KNCHEC0012), and the research permit was sought from the municipal primary education officer. Each participating child assented verbally after their parents signed an informed consent form (Appendices 3 and 4).

3.5 Tools and Measurements

3.5.1 Structured Questionnaire

A structured questionnaire was designed, comprised of socio-demographic characteristics, knowledge, attitude and practices on iodine consumption. The questionnaire involved iodine-rich foods, type of food sold; children's favorite foods; known essential minerals; the importance of iodine as a vital nutrient; the consequences of iodine deficiency, salt storage, and handling purchase as well as adding salt to food practices. The questionnaire was pre-tested, and it was updated based on the pre-testing results. A questionnaire on KAPs consisted of nineteen items for food vendors and ten items for children. For each correct answer, two marks were awarded and one for each wrong answer. Scores below and above mean were categorized as "good and poor knowledge," "good and bad attitude," and "good and poor practices of iodized salt use," respectively.

3.5.2 Focus Group Discussion (FGD)

In every school a total of two focus group discussions were conducted, one from class one and the other from class two. It was made a point to ensure that the places chosen for discussion were pleasant and devoid of distractions. All of the FGD were facilitated by the researcher, with one of the research assistants recording and the other observing the discussions. The focus groups lasted about half an hour on average. The results of the focus groups were compared to the quantitative data. Fifty-six children were involved in FGD eight from each selected school and, therefore, eight children aged 6-7 years old. The main aim was to gather critical information on food preferences and on table salt addition habit. A checklist was used to guide the discussion (Appendix 1).

3.5.3 Dietary Habits

Dietary information was collected by two dietary assessment methods, namely, a 24 hours dietary recall and the qualitative FFQ. In 24 hours, dietary recall participants were asked to recall all foods and drinks consumed in the past 24 hours. For FFQ, they were asked about their frequency of consumption of named junk foods over the previous seven days.

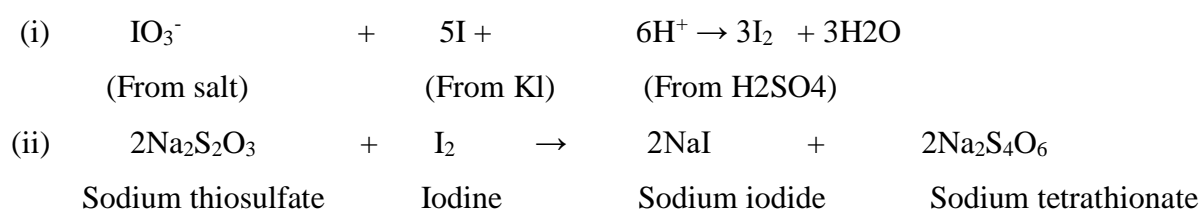
3.5.4 Anthropometric Measurements

Anthropometry was conducted following standard protocols (Cogill, 2003). Bodyweight was taken using a SECATM digital scale with a precision of 0.1 kg. The height was taken using SHORRTM two pieces height board at the nearest 0.1 cm. Participants were weighed in a light dress and without shoes. The WHO AnthroPlus was used to measure height and weight and compute body mass index z scores for age and sex (BMIZ). If the BMIZ was less than -2 standard deviations, the child was termed thin; if the BMIZ was greater than 1 SD, the child was labelled overweight or obese (De Onis *et al.*, 2004).

3.5.5 Salt Collection and Iodine Analysis

Salt samples were obtained from school food vendors, retail shops and household salts, and for iodine analysis. Food vendors were asked to provide two teaspoons of salt that they are using in a clean airtight plastic bag. For retail salts, the most common salt brands used was identified through questionnaire. This salt brand was then procured randomly from the nearby shops. All of the salt samples were kept in dark, clean sacks to ensure that there is no loss in the cause of transport. These salt samples were delivered to the TFNC laboratory while adhering to all iodine loss prevention measures. Each participating child brought two teaspoons of household salt in a clean airtight plastic bag provided a day before sample collection. Each salt sample was qualitatively screened for iodine content using MBI Rapid Test Kit (RTK) (WHO, 2007a). The kits consisted of a stabilized starch-based solution, one drop of the solution dripped onto a teaspoon of salt, and the color chart was used to classify the salt iodine and expressed in ppm (sufficient ≥ 15 ppm, medium < 15 ppm, and no iodine 0 ppm) (WHO, 2007a). Salt collected from school food vendors and at retail shops was analyzed quantitatively using an iodometric titration method (WHO, 2007a).

Mechanism of the reaction was of two steps: (i) Liberation of free iodine from salt and (ii) Titration of free iodine with thiosulfate



3.5.6 Urine Collection and Urinary Iodine Analysis

Urine samples were collected and handled, as proposed by Delange *et al.* (2002). Each child provided 15-20 ml of spot urine in a sterile, iodine-free 40 ml plastic universal urine container. An aliquot of urine (10 mL) was transferred to a plastic falcon tube with the child's ID number, date, and school name. The sample was then stored in a cool box at 4 °C and finally transported to TFNC and stored at -20 °C before analysis. Urinary iodine in duplicate was analyzed by a modified microplate method following Sandell-Kolthoff (S-K) reaction using ammonium persulfate as the oxidizing agent (Pino *et al.*, 1998). Both internal and external quality control (QC) materials were used to include high, medium, and low iodine concentration run between and within assays.

3.5.7 Statistical Data Analysis

Analysis of data was done using SPSS version 23 (Spss, 2011). Descriptive statistics were tabulated as numbers and percentages for categorical variables, continuous variables as the mean and standard deviation or as the median and inter-quartile range. Both parametric and non-parametric tests were used in testing hypotheses for continuous variables, one-way ANOVA for parametric test and Kruskal-Wallis and Mann-Whitney for the non-parametric test. The Kolmogorov-Smirnov test tested normality assumptions of how the variables are distributed. A Chi-square test was used in testing hypotheses for categorical variables. Iodine status within a group was compared using median UIC as per WHO recommendation.

For questionnaire on KAPs each correct answer, two marks were awarded and one for each wrong answer. Scores below and above mean were categorized as "good and poor knowledge," "good and bad attitude," and "good and poor practices of iodized salt use," respectively.

The bivariable and multivariable logistic regression model was used to evaluate factors associated with excess iodine intake (UIC >300 µg/L). Excess iodine intake was used in all models as the dependent variable, while independent variables were as tabulated (refer to tables). The Hosmer-Lemeshow statistic was used to test the goodness of fit of the model.

Results are tabulated as Odds Ratios (OR) and 95% confidence intervals. Statistically significant differences were considered at $p < 0.05$.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Sample Characteristics of Respondents

The study comprised 401 participants, 365 of whom were school children, and 36 food vendors. Of the pupils, 88.2% participated in the study, and 83.3% of the food vendors responded to questionnaires. The sex ratio between boys and girls was 1:1. The mean age of boys and girls (years), weight (kg) and height (cm) were 11.2 ± 2.4 , 34.5 ± 8.8 , 140 ± 11.5 , respectively. Only one school had school feeding program. Significant associations have been observed between socioeconomic status, age groups, and salt iodine content ($p < 0.05$) [Table 5].

For the sub-sampled population of the school children ($n=266$), Table 6 shows the association between iodine status with demographic and anthropometric variables. The girls' median UIC was significantly lower than in boys (386.0 vs. 414.48 $\mu\text{g/L}$, respectively; ($P = 0.04$). Consequently, the percentage of the participants with $\text{UIC} \geq 300$ $\mu\text{g/L}$ was lower in girls than in boys (45.4% vs. 54.6%), respectively. Based on WHO cut-off points for high iodine intake, results indicate that 73.8% of the children ≤ 12 years old had an intake above 300 $\mu\text{g/L}$. Overweight and obese children had a higher level of UIC than their counterparts (Table 6).

Table 5: Population Characteristics with Socioeconomic Status

Variables	Total	HSGs	LSGs	P value
Gender				
Boys (n; %)	158; 49.1	70; 44.3	88; 51.7	0.304 ^a
Girls (n; %)	164;51.9	67; 48.9	97;59.1	
Age (year; mean ± SD)	11.12 ± 2.37	10.94 ± 2.35	11.25 ± 2.38	0.249 ^b
Age group (n; %)				
6-8 years old	56; 17.4	24; 42.9	32; 57.1	0.01 ^a
9-11 years old	90; 28	52; 57.8	38; 42.2	
12-14 years old	176; 54.7	61; 34.7	115; 65.3	
Weight (kg; mean ± SD)	34.24 ± 8.84	34.25 ± 9.25	34.24 ± 8.48	0.995 ^b
Height (cm; mean ± SD)	140.0 ±11.55	139.62 ± 11.402	140.28 ± 11.68	0.610 ^b
BMI for Age (n; %)				
Underweight	42; 13.0	15; 35.7	27; 64.3	0.263 ^a
Healthy weight	241; 74.9	100; 41.5	141; 58.5	
Overweight	21; 6.5	12; 57.1	9; 42.9	
Obese	18; 5.6	10; 55.6	8; 44.4	
Family size				
≤ 5 family members	185; 57.5	77; 41.6	108; 58.4	0.733 ^a
> 5 family members	137; 42.5	60; 43.8	77; 56.2	
Family head				

Variables	Total	HSGs	LSGs	P value
Father	242; 75.1	112; 46.3	130;53.7	0.06 ^a
Mother	56; 17.4	18; 32.1	38; 67.9	
Other	24; 7.5	7; 29.2	17; 70.8	
Iodine level of household salt (ppm) [n=322]				
>= 15	280; 87.0	139; 48.9	145; 51.1	0.000 ^a
< 15	37; 12.5	6; 16.2	36; 83.8	
0	5; 1.4	1; 20	4; 80	
School feeding program (n; %)				
No	7; 87.5	3; 42.9	4; 57.1	0.067
Yes	1; 12.5	1; 100	0; 0	
Salt-Iodine levels from shops (ppm; mean ± SD) 53.94 ± 13.02				
Food vendors characteristics (n=30)				
Gender				
Male (n; %)	5; 16.7	3; 60	2; 40	0.304 ^a
Female (n; %)	25; 83.3	9; 36	16; 64	
Age (year; mean ± SD)	33.3 ±8.8	30.08 ± 6.37	35.5 ± 9.68	0.1 ^b
Abbreviations: ^a Chi-square; ^b Independent Samples t-Test; HSGs- High Socioeconomic Groups LSGs-Low Socioeconomic Groups				

Table 6: Socio-Demographic, Anthropometric and Urinary Iodine Status of children

Variables	UIC (µg/L)				P- value	UIC< 300	UIC	≥300	P- value	
	n	P25	Median	P75		µg/L n	%	µg/L n		%
Gender										
Boys	139	310.10	414.80	594.10	0.04 ^a	32	23	107	77	0.202 ^c
Girls	127	281.20	386.00	522.00		38	29.9	89	70.1	
Age category										
≤ 12 years old	168	298.50	394.45	529.50	0.545 ^a	44	26.2	124	73.8	0.952 ^c
> 12 years old	98	283.38	429.70	542.00		26	26.5	72	73.5	
BMI category										
Underweight	40	271.93	406.20	516.50	0.680 ^b	13	32.5	27	67.5	0.537 ^c
Normal BMI	201	296.00	397.80	497.23		53	26.4	148	73.6	
Overweight	18	316.75	397.30	497.23		3	16.7	15	83.3	
Obese	7	318.50	409.10	484.10		1	14.3	6	85.7	
Iodine level of household salt (ppm)										
≥15	224	298.50	406.55	540.45	0.537 ^b	58	25.9	166	74.1	0.774 ^c
< 15	37	287.25	359.80	569.90		10	27.0	27	73	
0	5	255.85	362.60	443.60		2	40.0	3	60	

Abbreviations: ^aMann-Whitneys; ^bKruskal-Wallis; ^cChi-square

4.1.2 Food Vendor's Knowledge and Practices Regarding Iodized Salt Utilization

(i) Food Vendor's Awareness of Nutrition, Health, Iodine-Rich Foods, and Iodized Salt

While iodized salt could be identified by 93.3% of food vendors, most 63.3% could not recognize problems related to iodine deficiency, and about 40% could do not know foods rich in iodine (Table 7). The food vendor's total awareness was 53.7%. Most (53.3%) knew what a balanced diet is. The primary source of knowledge is the radio and television (50%). The type of food most sold to school children by these food vendors is junk foods (70%), [Table 7].

Table 7: Knowledge of Food Vendors on Nutrition, Health and Iodized Salt

Variables	Category	Frequency	Percentage
Knowledge	Good	16	53.3
	Poor	14	46.7
Awareness on balanced diet	No	14	46.7
	Yes	16	53.3
Foods most sold to the child	Junk foods*	21	70
	Healthy foods**	9	30
Awareness on iodine-rich foods	No	18	60
	Yes	12	40
Awareness on iodized salt	No	2	6.7
	Yes	28	93.3
Source of information on Iodized salt (n=28)	Radio	7	25
	T.V and Radio	14	50
	TV	2	7.1
	School	5	17.9
Awareness on IDD	No	19	63.3
	Yes	11	33.7
Believed every salt contains iodine	Yes	9	30
	No	14	46.7
	Do not know	7	23.3
Importance of iodized salt in the diet	Very important	11	36.7
	Somewhat important	15	50.0
	Not at all important	3	10.0
	No response	1	3.3

***Junk foods:** Are energy-dense foods with high fat/sugar/salt content and low nutrients value in fiber, protein, mineral content, and vitamin content. Examples are potato chips, fried cassava, kachori popcorn, and the like.

****Healthy foods:** Are nutrient-dense foods with low fat/sugar/salt content and high nutrients value in fiber, protein, mineral content, and vitamin content. Examples are fruits and vegetables.

(ii) Attitude on Iodized Salt Utilization

The percentage of good attitude of iodized salt utilization was only 60%. Most of the food vendors prefer packed salt (46.3%) than unpacked one (Table 8).

(iii) Practice on Iodized Salt Utilization

The percentage of correct use of iodized salt among food vendors was 36.7%, and 86.1% of the salt samples were adequately iodized (Table 9). Only 16.7% of food vendors were buying salt based on iodization status. The majority bought any type of salt without considering whether it is iodized or not. Only 40% of food vendors store salt in a jar with a lid. Significantly, just a few of them (33.3%) add salt as recommended at the end of cooking (Table 9).

Table 8: Attitude of the Study Participants on Iodized Salt Consumption

Variables	Category	Frequency	Percentage
Attitude	Good	12	60
	Bad	18	40
Opinion on salt preference	Packed salt	14	46.3
	Unpacked salt	6	20
	No response	10	33.3
Reason for salt preference	Iodized/Non-iodized	5	16.7
	Price	2	6.7
	Brand	2	6.7
	Any salt	21	70
Importance of iodized salt in your diet	Very important	13	43.3
	Somewhat important	3	10
	Not at all important	2	6.7
	No response	12	40

Table 9: Practice on Iodized Salt Utilization

Variables	Category	Frequency	Percentage
Salt iodine content (ppm)	≥ 15	23	76.7
	< 15	7	23.3
Practices	Good	11	36.7
	Poor	19	63.3
Factors considered in buying salt	Iodized/Non-iodized	5	16.7
	Price	2	6.7
	Brand	2	6.7
	Any salt	21	70
Salt brand used	Brand A	22	73.3
	Brand B	3	10
	Brand C	5	16.7
Type of salt used	Iodized packed salt	30	100
	Coarse salt (Non packed)	0	0
Salt storage material	With closed container	12	40
	Without closed container	18	60
Addition of salt in cooking	Beginning	4	13.3
	Middle	16	53.3
	At the end of cooking	10	33.3
How often do pupils Ask for additional salt	Always	2	6.7
	Often	20	66.7
	Sometimes	5	16.6
	Rarely /Never	3	10

(iv) Factors Associated with Knowledge and Practice of Iodized Salt Utilization among Food Vendors

The mean score on knowledge was 15.6 ± 4.2 , and that of practice was 11.2 ± 0.9 . Knowledge regarding iodized salt consumption was significantly associated with socioeconomic status, gender, age group, educational level, and marital status ($P < 0.05$). The proportion of proper use of iodized salt among food vendors was 36.7%. Proper use of iodized salt among food vendors who sell food to schools located in slum areas was significantly lower than their counterparts ($P < 0.05$) [Table 10]. There were significant associations between the location of the school, age groups, and salt iodine content ($p < 0.005$) [Table 10].

Table 10: Factors Associated with Knowledge and Practice on Use of Iodized Salt among Food Vendors

Variables	Category	Knowledge				Practice			
		Good (n ;%)	Poor (n ;%)	χ^2	p	Good (n; %)	Poor (n %)	χ^2	p
Socioeconomic status	HSGs	11;91.7	1;8.3	11.8	0.001	9;75	3;25	12.7	0.000
	LSGs	5;27.8	13;72.2			2;11.1	16;88.9		
Gender	Male	5;100	0; 0	5.3	0.022	1;20	4;80	0.7	0.397
	Female	11;44	14;56			10;40	15;60		
Age group	< 30 years	11;91.7	1;8.3	11.8	0.001	6;50	6;50	1.5	0.216
	>30 years	5;27.8	13;72.2			5;27.8	13;72.2		
Educational level	Non	0; 0	2;100	8.2	0.016	0; 0	2;100	1.3	0.524
	Primary	6;37.5	10;62.5			6;37.5	10;62.5		
	Secondary	10;83.3	2;16.7			5;41.7	7;58.3		
Marital status	Married	4;33.3	8;66.7	10.4	0.015	2;16.7	10;83.3	3.8	0.289
	Widowed	1;50	1;50			1;50	1;50		
	Divorced	1;20	4;80			2;60	3;40		
	Single	10;90.9	1;9.1			6;45.5	5;45.5		
Sells per day in TZS	Less than 5000	0; 0	2;100	3.1	0.218	0; 0	2;100	1.7	0.458
	Between 5000 and 10 000	3;75	1;25			1;25	3;75		
	Above 10 000	13;54.2	11;45.8			10;41.7	14;58.3		

Abbreviations: HSGs- High Socioeconomic Groups; LSGs-Low Socioeconomic Groups; χ^2 - Chi-square test

4.1.3 Dietary Intake and Lifestyle Behaviors of Schoolchildren

School children aged 8-14 years (n= 266) were asked different questions about healthy foods, foods rich in iodine, and discretionary salt use. Most of them (75.6%) mentioned potato chips, fried cassava, and kachori (a spicy snack consisting of Irish potatoes, flour, garlic clove turmeric powder, salt, and oil) as their favorite foods. Only 14.3% of children could name iodine among the three essential trace elements needed by the body to function properly. About 25.6% of the pupils were able to mention IDD among nutritional deficiency disorders they know. Besides, 87% knew that the amount of iodine decreases when salt is in open containers. It was also noted that about 67.3% of children add salt on eating (Table 11).

Focus Group Discussion (FGD) findings (n=56) showed that children were aware of iodized salt, with only a few being aware of the effects of not using iodized salt. It was also noted that most children prefer buying fried foods versus nutritious foods, such as chips, cassava, and kachori. Primarily such foods were consumed away from home. They typically add salt while eating chips and fried cassava since these foods are traditionally prepared without adding salt.

Table 11: Children's Awareness of Health, Nutrition, Iodine-Rich Foods and Iodized Salt (n=266)

Variables	Category	Frequency	Percentage
Salt iodine content (ppm)	≥ 15	280	87
	< 15	37	11.5
	0	5	1.6
Knowledge	Good	124	46.6
	Poor	142	53.4
Ever taught about a nutrition topic	No	38	14.3
	Yes	228	85.7
Favorite food	Healthy foods	65	25.5
	Junk foods	201	75.5
Reasons for favorite	Availability	5	1.9
	Healthy	54	20.3
	Savory	120	45.1
	Taste good/sweet	63	23.7
	No reasons	24	9.0
Mentioned iodine among three essential minerals	No	228	85.7
	Yes	38	14.3
Mentioned IDD among nutritional deficiency disorders	No	198	74.4
	Yes	68	25.6
Salt is a good source of iodine	No	198	70.7
	Yes	68	15.8
	Do not know	198	13.5
All salt contains iodine	No	39	14.7
	Yes	183	68.8
	Do not know	44	16.5
Salt is a good source of iodine	No	198	70.7
	Yes	68	15.8
Iodine content reduces when salt is left uncovered	Yes	87	32.7
	No	104	39.1
	Do not know	75	28.2
Usually adding salt to food	No	87	32.7
	Yes	179	67.3

4.1.4 Iodine Nutrition Status of School Children

(i) Iodine Nutrition Status by Socio-economic Groups

The World Health Organization classify a median UIC of $< 100 \mu\text{g/L}$ as insufficient intake, $100-199 \mu\text{g/L}$ as adequate intake, $200-299 \mu\text{g/L}$ as more than adequate, and $\geq 300 \mu\text{g/L}$ as excess intake. The results show that the median UIC was $401 \mu\text{g/L}$, indicating excessive iodine

intake. The median UIC between the two groups had no significant differences, ranging from 420.6 $\mu\text{g/L}$ in HSGs to 389.6 $\mu\text{g/L}$ in LSGs. Based on the UIC category, the proportion of children with UIC above 300 $\mu\text{g/L}$ was 73.7%. Furthermore, only 1% of the studied population had insufficient iodine intake (Fig. 4).

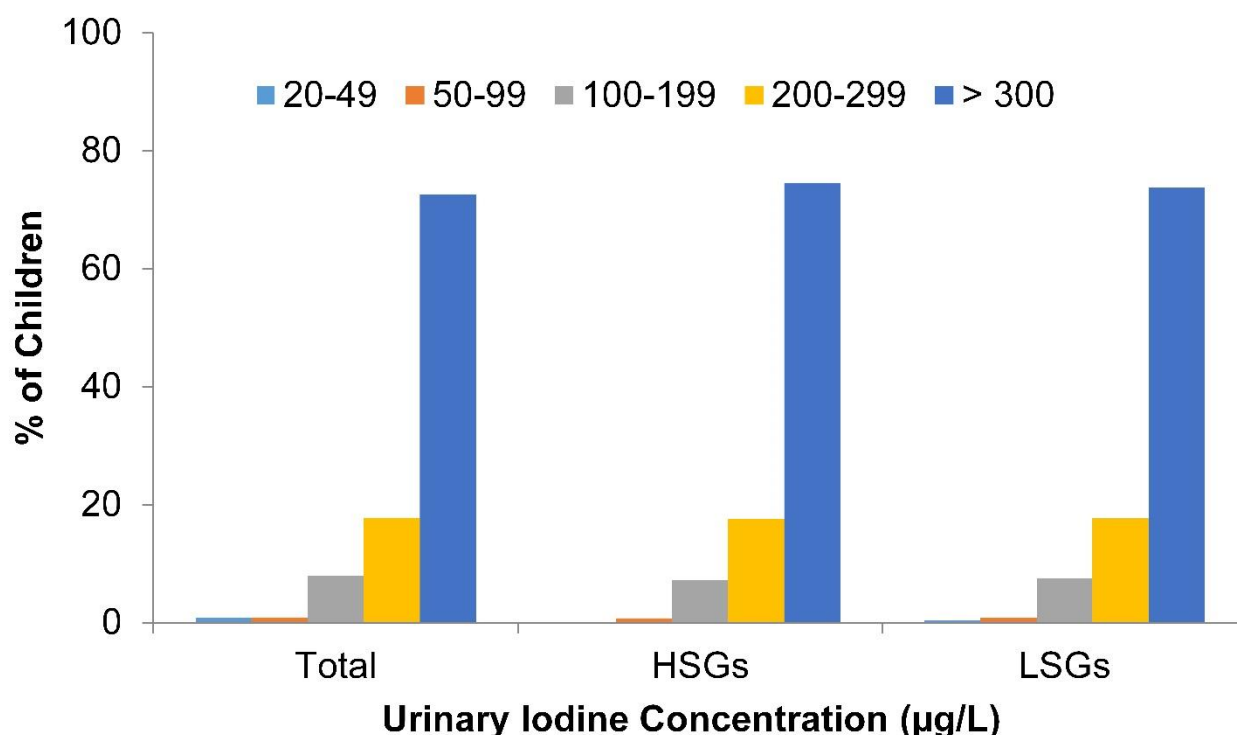


Figure 3: Urinary Iodine Concentration among Schoolchildren Based on WHO (2007) Classification for Iodine Adequacy

(ii) Iodine Status by 24 Hours Dietary Recall

All children consume cereal-based foods, only 4% of the children consume fruits and 29.3% vegetables. While cabbage consumption was significantly associated with low iodine intake ($P < 0.001$), salty snack consumption was significantly associated with high iodine intake ($P < 0.001$). The median UIC of children consumed salty snacks was significantly higher than their counterparts (425.65 vs. 371.85 $\mu\text{g/L}$, respectively; $p = 0.01$) (Table 12). Consequently, the proportion of the UIC population above 300 $\mu\text{g/L}$ was significantly higher in salty snacks consumers than non-consumers (81.7% vs. 64.5%, respectively; $p = 0.002$).

Table 12: Children Iodine Status by 24 Hours Dietary Recall

Variables		UIC (µg/L)				P-value	UIC < 300 µg/L		UIC ≥ 300 µg/L		P-value
		n	P25	Median	P75		n	%	n	%	
Cereals	Yes	266	296.450	401.250	540.550	-	70	26.3	196	73.7	0.015 ^b
	No	-					-	-	-	-	
Bread	Yes	50	329.08	411.70	530.50	0.638 ^a	9	18.0	41	82.0	0.0138 ^b
	No	216	286.25	398.45	543.85		61	28.2	155	71.8	
Root/Tubers	Yes	164	299.45	400.25	543.85	0.810 ^a	42	25.6	122	74.4	0.775 ^b
	No	102	292.93	401.40	531.25		28	27.5	74	72.5	
Pulses/Legumes	Yes	152	306.83	411.75	540.85	0.305 ^a	36	23.7	116	76.3	0.265 ^b
	No	114	290.85	393.75	534.58		34	29.8	80	70.2	
Salty snacks	Yes	142	324.00	425.65	568.90	0.01 ^a	26	18.3	116	81.7	0.002 ^b
	No	124	265.93	371.85	510.40		44	35.5	80	64.5	
Meat	Yes	86	296.68	382.00	487.33	0.104 ^a	23	26.7	63	73.3	0.913 ^b
	No	180	295.55	413.20	570.90		47	26.1	133	73.9	
Fish	Yes	75	310.10	430.80	548.00	0.254 ^a	17	22.7	58	77.3	0.397 ^b
	No	191	292.10	390.50	530.00		53	27.7	138	72.3	
Eggs	Yes	17	282.40	399.10	648.40	0.969 ^a	6	35.3	11	64.7	0.385 ^b
	No	249	298.80	401.40	538.05		64	25.7	185	74.3	
Milk and milk product	Yes	20	257.75	318.10	502.55	0.197 ^a	9	45.0	11	55.0	0.048 ^b
	No	246	300.43	405.55	542.00		61	24.8	185	75.2	
Vegetables	Yes	78	283.40	387.70	513.85	0.207 ^a	23	29.5	55	70.5	0.449 ^b
	No	226	299.88	412.40	548.75		47	25.0	141	75.0	
Cabbage	Yes	40	176.13	234.75	298.18	P<0.001 ^a	31	77.5	9	22.5	P<0.001 ^b
	No	251	330.25	429.95	572.18		39	17.3	187	82.7	
	Yes	11	276.70	351.00	484.10	0.234 ^a	5	45.5	6	54.5	0.141 ^b

Variables		UIC (µg/L)				P-value	UIC < 300 µg/L		UIC ≥ 300 µg/L		P-value
		n	P25	Median	P75		n	%	n	%	
Fruits	No	255	299.40	401.70	548.00	0.708 ^a	65	25.5	190	74.5	0.824 ^b
	Yes	111	288.00	401.40	527.00		30	27.0	81	73.0	
Sugar	No	155	299.40	401.10	558.40	0.762 ^a	40	25.8	115	74.2	0.057 ^b
	Yes	12	231.18	349.35	671.73		6	50.0	6	50.0	
Carbonated drinks	No	254	299.10	401.55	536.88	0.144 ^a	64	25.2	190	74.8	0.373 ^b
	Yes	39	310.10	471.30	605.80		8	20.5	31	79.5	
Juice	No	227	293.80	396.00	523.00		62	27.3	165	72.7	

Abbreviation: ^aMann-Whitney and ^bChi-square test

(iii) Children Iodine Status and Frequency of Consumption of Junk Foods

Potato chips, fried cassava, kachori, and groundnuts had a significant association with iodine status. Evaluation of the effect of chips consumption on UIC indicates that 46.5% of the children who never consumed chips in the previous week had UIC $<300 \mu\text{g/L}$. This cluster corresponds to 32.3% of the population. In comparison, 46.5% of children in this group who never eat potato chips and only 20.2% of children who eat at least once a week had UIC $< 300 \mu\text{g/L}$ ($p < 0.001$) [Table 13].

As anticipated, the risk of having UIC $>300 \mu\text{g/L}$ were significantly associated with chips and fried cassava consumption. The odds of having UIC $>300 \mu\text{g/L}$ increases with the number of frequencies of consumption. Compared to those who never consume potato chips, those who consumed for 1-3 days/ week have 5.07 times higher odds of having high iodine intake (OR=5.07; 95% CI (2.32 to 11.1); $p < 0.001$). Children who consumed for 4-7 days/ week have 8.51 times higher odds of having high iodine intake (OR=8.51; 95% CI (3.3 to 21.99; $p < 0.001$). For fried cassava, those who consumed for 4-7 days/week had 8.82 times higher odds than non-consumers (OR = 8.82; 95% CI (2.658-29.286); $p < 0.001$). Also, children who add table salt on consumption have 1.8 times higher odds of having UIC > 300 than those who do not usually add table salt OR = 1.83; 95% CI (1.04- 3.22); $p = 0.036$) [Table 14].

Table 13: Dietary Habits and Urinary Iodine Status

Variables		UIC (µg/L)					P-value	UIC < 300 µg/L		UIC ≥ 300 µg/L		P-value
		n	%	P25	Median	P75		n	%	n	%	
Chips	Never	86	32.3	231.2	320.3	424.1	0.000 ^a	40	46.5	46	53.5	p<0.001 ^c
	1-3 days/week	104	39.1	230.9	397.6	526.4		21	20.2	83	79.8	
	4-7 days/week	76	28.6	390.2	528.9	706.6		9	11.8	67	88.2	
Fried cassava	Never	109	41.0	237.5	339.5	436.1	0.000 ^a	47	43.1	62	56.9	p<0.001 ^c
	1-3 days/week	103	38.7	326.8	429.3	531.1		18	17.5	85	82.5	
	4-7 days/week	54	20.3	374.9	522.5	925.25		5	9.3	49	90.7	
Kachori	Never	164	61.7	272.1	364.7	495.4	0.000 ^a	51	31.1	113	68.9	0.043 ^c
	1-3 days/week	68	25.6	311.6	461.2	613.4		15	22.1	53	77.9	
	4-7 days/week	34	12.8	370.1	463.5	686.0		4	11.8	30	88.2	
Bread	Never	146	54.9	293.7	387.7	556.6	0.759 ^a	41	28.1	105	71.9	0.573 ^c
	1-3 days/week	84	31.6	287.8	410.9	522.3		22	26.2	62	73.8	
	4-7 days/week	36	13.5	328.5	414.6	518.5		7	19.4	29	80.6	
Groundnuts	Never	167	62.8	313.3	406.1	535.7	0.668 ^a	36	21.6	131	78.4	0.059 ^c
	1-3 days/week	79	29.7	264.9	387.7	545.0		26	32.9	53	67.1	
	4-7 days/week	20	7.5	243.0	400.6	583.8		8	40.0	12	60.0	
Popcorn	Never	223	83.8	301.5	407.0	535.7	0.465 ^a	54	24.2	169	75.8	0.206 ^b
	1-3 days/week	38	14.3	246.5	329.5	576.4		14	36.8	24	63.2	
	4-7 days/week	5	1.9	254.0	351.0	650.8		2	40.0	3	60.0	
Bagia	Never	223	83.8	298.2	394.6	531.1	0.021 ^c	58	26.0	165	74.0	0.562 ^c
	1-3 days/week	31	11.7	284.3	416.6	522.0		10	32.3	21	67.7	
	4-7 days/week	12	4.5	482.5	630.0	917.6		2	16.7	10	83.3	
Ice cream	Never	149	56.0	305.8	404.4	561.4	0.885 ^a	34	22.8	115	77.2	0.300 ^c
	1-3 days/week	88	33.1	291.9	404.4	519.7		26	29.5	62	70.5	
	4-7 days/week	29	10.9	237.3	396.1	688.7		10	34.5	19	65.5	
Samosa	Never	137	51.5	298.8	401.4	557.95	0.088 ^a	35	25.5	102	74.5	0.284 ^b
	1-3 days/week	90	33.8	268.9	374.1	487.3		28	31.1	62	68.9	
	4-7 days/week	39	14.7	330.4	441.8	605.8		7	17.9	32	82.1	
Usually, add table salt	No	87	32.7	235.0	406.1	595.1	0.434 ^b	30	34.5	57	65.5	0.035 ^c
	Yes	179	67.3	314.4	401.1	526.7		40	22.3	139	77.7	

Abbreviations: ^aKruskal-Wallis; ^bMann-Whitneys; ^cChi-square

Table 14: Logistic Regression Models for the Relation between UIC > 300 µg/L and Frequency of Consumption of Various Food Products

Variables		Crude OR (95% CI)	Adjusted OR (95% CI)
Chips	Never	1.00	
	1-3 days/week	3.44 (1.81-6.51) **	5.12 (2.41-10.87) **
	4-7 days/week	6.47 (2.87-14.62)	9.04 (3.61-22.63) **
Fried cassava	Never	1.00	1.00
	1-3 days/week	3.58 (1.90-6.75) **	4.87 (2.36-10.05) **
	4-7 days/week	7.43 (2.75-20.10)	11.08 (3.45-35.54) **
Kachori	Never	1.00	
	1-3 days/week	1.60 (0.82-3.09) *	
	4-7 days/week	3.39 (1.13-10.11)	
Bread	Never	1.00	
	1-3 days/week	1.10 (0.60-2.02)	
	4-7 days/week	1.62 (0.66-3.98)	
Groundnuts	Never	1.00	1.00
	1-3 days/week	0.56 (0.39-1.02)	0.54 (0.26-1.11)
	4-7 days/week	0.41 (0.16-1.09)	0.30 (0.09-1.00) **
Popcorn	Never	1.00	
	1-3 days/week	0.55 (0.27-1.13)	
	4-7 days/week	0.48 (0.08-2.94)	
Bagia	Never	1.00	
	1-3 days/week	0.74 (0.33-1.66)	
	4-7 days/week	1.76 (0.37-8.26)	
Ice cream	Never	1.00	1.00
	1-3 days/week	0.71 (0.39-1.28)	0.62 (0.31-1.25)
	4-7 days/week	0.56 (0.24-1.32)	0.37 (0.12-1.15)
Samosa	Never	1.00	1.00
	1-3 days/week	0.76 (0.42-1.37)	0.54 (0.26 -1.1)
	4-7 days/week	1.57 (0.67-3.87)	1.28 (0.44-3.79)
Usually, add table salt	No	1.00	
	Yes	1.83 (1.04- 3.22) *	

Notes: **Statistically significant at p value <0.01 and *statistically significant at p value <0.05.

Abbreviations: COR, crude odds ratio; AOR, adjusted odds ratio and C.I, confidence interval.

4.2 Discussion

4.2.1 Knowledge, Attitude and Practice of Iodized Salt Utilization by Food Vendors

This study found that half (53.3%) of food vendors had good knowledge on the importance of iodized salt and other health and nutrition issues. This finding is lower compared to 92.6% reported from the Southern Highlands of Tanzania (Mosha *et al.*, 2004). The variation might be due to the nature of study settings in that the previous study focused on the areas previously identified as endemic iodine-deficient regions. These areas received a great deal of support from government and non-governmental organizations, where respondents had more opportunities to increase their exposure through media promotion of iodized salt. The difference in study participants and households against food vendors in the present study could also explain the discrepancy.

Information regarding iodine nutrition knowledge among food vendors is lacking in Tanzania and elsewhere despite their contribution to meal provision. Excluding this group in national surveys and local studies could miss out essential and useful information for optimizing the population's iodine nutrition status. The present findings explored food vendors' general understanding of iodized salt, health, and nutrition, showing that their knowledge is lower than studies in households. Thus, intervention pertaining IDD control program should also focus on this group.

Proper use of adequately iodized salt is critical in IDD interventions. Nevertheless, the appropriate practice of using iodized salt in this study was significantly lower (36.7%) compared to the global and national target of 95% (WHO, 2007b). Adequately iodized salt should be applied after cooking has been completed (Rana & Raghuvanshi, 2013), though if they did this, then they would have more high levels of iodine. Nevertheless, in this study, most add salt at the middle (53.3%), while few (33.3%) add at the end of cooking. The study is aligned with another study done in Northwest Ethiopia, whereby only 25.7% correctly use iodized salt that is at the end of cooking (Tariku & Mazengia, 2019). It is now time to consider food vendors in future IDD intervention studies by creating awareness of iodized salt's proper use.

Respondents from schools in the low socioeconomic area were more likely to have inadequate knowledge than their counterparts. This could entail improved literacy and access to the media among people with better socio-economic status, which increased their understanding of the nutrition aspects and access to information, respectively. A study by Bhattacharya and Chandra (2019) and Marwaha *et al.* (2003) reported total goiter prevalence to be higher in lower socioeconomic status households. As expected, our study's median UIC observed is higher in high socio-economic status than their counterpart.

4.2.2 Household and Food Vendors' Iodized Salt Coverage

The most effective and sustainable strategy for IDD control is the iodization of salt (WHO, 2007b). Accordingly, reinforcing salt iodization programs and improving control and monitoring system is a critical step in eradicating the problem (WHO, 2007b). Total eradication is achieved if more than 90% of households use iodized salt (WHO, 2007b). Nevertheless, food prepared/purchased outside the home is becoming an essential component of the diet in many countries, predominantly urban areas. The present study, therefore, included salt used by food vendors.

The findings show that 87.0% and 76.6% of households and food vendors, respectively, were using adequately iodized salt. These results are lower than the national and global targets for achieving more than 90% use of adequately iodized salt (WHO, 2007a). However, household iodized salt utilization found in this study (87.0%) is higher than that found by (Farebrother *et al.*, 2018) in 2018. This is possibly due to the government's increased efforts to ensure iodized salt availability and promote iodized salt's health benefit through local media to convey the required iodine awareness to the public.

The availability of adequately iodized salt among food vendors (76.7%) is significantly lower than that of households in Kinondoni (87.0%), Iringa Tanzania (95%) (Mosha *et al.*, 2004) and Nigeria (97.5%) (Adejo & Enemali, 2013). Food vendors' poor practices towards iodized salt use and without using a salt container with a lid by 60% might expound the difference. These results further explain the need to include food vendors in future iodine national surveys for the population's optimal iodine intake.

4.2.3 Dietary Intake and Lifestyle Behaviors of Schoolchildren

Consumption of junk foods is predominant among school children in the Kinondoni municipality. They occupy a large and disproportionate space of schoolchildren's plate while consuming nutrient-rich, high-fiber foods like vegetables and fruits are under-consumed (Ambrosini *et al.*, 2012). This study's findings revealed that 70% of all food sold around the school compounds are junk foods. They include potato chips, fried cassava, kachori, sausage, samosa, and popcorn. Unsurprisingly, 6.5% and 5.6% of the studied schoolchildren were overweight and obese respectively. However, 13% are underweight indicating double burden of malnutrition. Other previous studies done in Tanzania and elsewhere confirmed the dual burden of malnutrition (Mosha & Fungo, 2010; Muhihi *et al.*, 2013; Njelekela *et al.*, 2015; Pangani *et al.*, 2016; Tzioumis & Adair, 2014).

Globally, consumption of junk foods is now growing at an increasing rate especially among children leading to childhood obesity and its associated conditions (Kaushik *et al.*, 2011; Maletnlema, 2002; Popkin & Hawkes, 2016). In this study and other studies (Braithwaite *et al.*, 2014; Bundhun *et al.*, 2018; Gupta *et al.*, 2018; Kigaru *et al.*, 2015), it is clear that the majority of the pupils eat junk foods than healthy foods while at school. Moreover, 67.3% of the studied population adds raw salt on consumption, which may expose children to high iodine intake, especially if they have high iodine content.

Introducing the school feeding program could not only improve learning abilities and children's attendance but also controls the quality and type of food given to children. Unfortunately, 87.5% of the primary schools studied had no school-feeding program leading to uncontrolled meal pattern. Nutritionally, healthy eating usually has a significant role in a child's health and well-being (Kumar & Preetha, 2012). A child's health is strongly influenced by his or her eating habits, and lifestyle behaviors developed during childhood are known to continue to adulthood (Neumark-Sztainer *et al.*, 2011). The intake of the required amount of sufficient macro- and micro-nutrients is also a pre-requisite for effective nutrition among children.

The present study examined nutrition, health, iodine-rich foods, and iodized salt use among school children. Only 46.6% had good knowledge of nutrition, health, iodine-rich food, and iodized salt use based on the questions asked. This study is aligned with that done in Kenya, whereby pupils had moderate nutrition knowledge (Kigaru *et al.*, 2015). Despite differences in the type of item between the two studies where the findings showed that most school children

are unaware of nutrition issues. For instance, in this study, 85.7% of the pupils acknowledged having been taught nutrition at school. Surprisingly only a few (14.3%) mentioned iodine among the three essential trace elements. This shows that iodine is not among the most known essential trace elements to them. Integrating nutritional issues and establishing nutrition clubs in primary schools would promote nutritional knowledge in different ways and the development of healthy eating habits in children. Imparting nutrition knowledge to this age group is vital for their future nutritional outcome (Bundhun *et al.*, 2018).

4.2.4 Iodine Status of Schoolchildren

For the total elimination of IDD, regular iodine nutrition assessment is recommended (WHO, 2007a). The present study assessed the iodine nutritional status through determining the urinary iodine concentration of the schoolchildren. The median UIC was 401 µg/L, indicating excessive iodine consumption in the studied population group according to WHO standards. While in 2013, pupils in the Kinondoni municipality had a median UIC of 388 µg/L (Zimmermann *et al.*, 2013). The present study indicates an increase from 388 µg/L to 401 µg/L, and only 1.1% has insufficient iodine intake. The last published Tanzania national iodine survey (Assey *et al.*, 2009) revealed that the median UIC was 203.6 µg/L indicating more than adequate intake. The study by Assey and Peterson (2009) also reported that 35% of school-aged children in Tanzania had UIC > 300 µg /L, which differs significantly from 73.7% in this study. Due to lifestyle changes over the years, the prevalence of excess iodine intake among pupils might have increased.

Excess iodine consumption is associated with an increased risk of hyperthyroidism and autoimmune thyroid disorders, although, in most cases, the body can tolerate (Leung & Braverman, 2014). In people with present or past thyroid disorders, only small iodine intake changes may trigger thyroid disorders (Emder & Jack, 2011). Generally, in countries previously identified as iodine insufficient like Tanzania, iodine consumption is recommended not to exceed 500 µg/day (WHO, 2007a). Nonetheless, it is understood that the benefits of avoiding the consequences of iodine deficiency overshadow the side effects of slightly excessive iodine intake (Andersson *et al.*, 2007). While this may be of concern in Tanzania because about one-third of the population studied had UIC > 500 µg/L, it is crucial to monitor this population in the upcoming iodine deficiency monitoring and control program.

4.2.5 Universal Salt Iodization and Excessive Iodine Intake

In some countries where the fortification of salt is mandatory, the incidence of excessive iodine consumption among school-aged children has increased (Assey *et al.*, 2009; Duarte *et al.*, 2009; Seal *et al.*, 2006; Zimmermann *et al.*, 2013). This increase is significant, and it needs the strengthening of monitoring systems in iodine deficiency control programs, such as adjusting iodine concentration in fortified salt. Attaining adequate iodine nutrition in a community that consumes 10 g of salt per day, 20-40 ppm of iodine is recommended at the production level (WHO, 2007a). However, the existing regulation on salt iodization in Tanzania is 40-80 ppm and 25-70 ppm at production and point of sales, respectively (TFDA, 2010). With the current nutrition transition, coupled with the high discretionary salt intake through junk foods (67.3%), improved market chains, and salt handling practices, users are likely to be exposed to high iodine intake.

Our study further noticed that the mean iodine content of the selected commonly used salt brands by food vendors and households at the point of sales was above 25-40 ppm as required by WHO, indicating over iodization. Since discretionary salt intake is high (67.3%), then could explain the existing excess iodine intake. Interventions are therefore required to reduce iodine consumption by reducing iodine concentration added to salt during the iodization process, like in Kenya and Brazil (Kenya National Bureau of Statistics (KNBS), 2018; Oliveira, 2017).

4.2.6 Junk Foods and High Iodine Intake

Our study found the association between potato chips and fried cassava consumption and excessive iodine intake among schoolchildren. The odds of most frequently consuming potato chips were 9.4 times higher compared to those who never consumed. Inherently, potatoes and cassava do not contain much iodine enough to cause excess intake (Haldimann *et al.*, 2005). Thus, the excess consumption may be caused by discretionary salt added to these foods during consumption (Thomson, 2009). Although the study did not quantify the amount of sodium/iodine in these foods, a previous study by Lobanco *et al.* (2009) indicated that the sodium content of potato chips is 62.3 mg/100 g (Lobanco *et al.*, 2009), and contribute to more than 2% of salt intake in children (Thomson, 2009). Exposure to this food daily could lead to excess iodine intake.

4.3 Study Limitations

- (i) The tool used in collecting food frequency took account of foods eaten in the past seven days, which may be difficult for the participants to remember; therefore, interviewers used probes and cues to improve the accuracy of food data collected.
- (ii) The study did not quantify the amount of iodine consumed through discretionary foods and salts.
- (iii) Salt samples collected were meant to come from their homes; however, some children may have taken salt from their friends, which might affect the results.
- (iv) The present study somewhat uses a small sample for food vendors; thus, it may not reflect the current situation concerning knowledge and practice of salt iodization of food vendors in Tanzania.
- (v) Cross-sectional nature of this study does not show casualty of predictors to the outcome variable

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the finding, low knowledge and practice of iodized salt utilization persist steadily in the study area relative to WHO standard. The substantial achievement in awareness creation of the importance of using iodized salt is observed through the proper use of iodized salt that remains relatively low, particularly among food vendors. Poor socioeconomic status and educational levels continue to be associated with inadequate knowledge and practices of iodized salt utilization among respondents.

Inferred dietary iodine intake showed that children consumed adequate amounts of dietary iodine, although one-third of children consumed above the upper limit of 500 ug/day. A better school feeding environment/program would help pupils shape their nutritional habits and meet their daily nutrient requirements. Most of the food sold within the school compound was junk food. The study highlighted junk foods' consumption as the significant iodine dietary source, resulting from adding iodized salt. Nevertheless, iodine levels added to salt in Tanzania remained above the recommended level despite observed high iodine intake.

5.2 Recommendations

- (i) The evidence of excessive iodine intakes in populations observed in previous studies, and this study should alert the policymakers to consider adjustment of the amount of iodine added to salt.
- (ii) The policy should start to concentrate on reducing salt intakes in line with WHO recommendations.
- (iii) To encourage healthy eating habits, there is a need to improve school feeding programs and change the current food environments in schools.
- (iv) Improving people's livelihoods and the awareness of the proper use of iodized salt among all food handlers can be a permanent and essential strategy for solving IDD's public health problems.

- (v) Further studies on knowledge and practice of iodized salt utilization by food vendors should be done with a large sample size using mixed methods approaches, and salt iodine levels should be assessed.
- (vi) Future studies in Tanzania should also focus on qualitative and quantitative dietary assessment, household per capita salt intake, the use of iodized salt in processed foods, and the iodine content of the commonly consumed junk foods.
- (vii) There is a need for constant monitoring (by policy makers) of salt iodation practices by salt producers to see whether they properly iodize salt.
- (viii) Proper implementation of salt law to punish those salt producers who don't adhere to adequate salt iodization procedures.
- (ix) A need to conduct a national survey on iodine status will guide possible adjustment of the amount of iodine to be added to salt during salt iodization.

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APPENDICES

Appendix 1: Questionnaire to Assess Iodine Status and Dietary Habits among Primary School Children, Kinondoni Tanzania

Participant ID.....(Should be the same as that of a child ID)

PART A: Demographic Information of the Parents/Care giver			
1	Sex	Male.....1 Female.....2	
2	What is a date of birth of your child?	
4	What is your level of education?	Non.....1 Primary2 Secondary3 Tertiary.....4	
5	What is your marital status?	Married.....1 Widowed.....2 Divorced.....3 Single.....4	
6	What is your occupation status?	Farmer.....1 Trader.....2 Civil servants.....3 Other (specify).....4	
7	What is the size of the household?	
8	What is the level of your income?	< 75,000 per month.....1 ≥ 75,000 per month.....2	
PART B: Medical History:			
9	Have your child ever been diagnosed with any of the following conditions:	i. Goiter (enlarged thyroid) Yes.....1 No.....2 I don't know.....3 ii. Hyperthyroidism Yes.....1 No.....2 I don't know.....3 iv. Hypothyroidism Yes.....1 No.....2 I don't know.....3 v. Thyroid nodule Yes.....1 No.....2 I don't know.....3 vi. Thyroid cancer	

		Yes.....1 No.....2 I don't know.....3	
10	In the last 3 months, have your child taken thyroid hormone pills (L-thyroxine, Synthroid, Levoxyl, Unithroid, Levothroid, Cytomel, or Armour thyroid)?	Yes.....1 No.....2 I don't know.....3	
11	In the last week, have you used any iodine-containing (brown-colored) antiseptic skin cleaner?	Yes.....1 No.....2 I don't know.....3	
Part C: Knowledge, Attitude and Practices, With Regard to IDD and Intake of Iodized Salt (To be filled by food vendors)			
KNOWLEDGE			
12	Can you please tell me what iodine is	Vitamin.....1 Mineral.....2 Micronutrient.....3 Something in the food that we eat.....4 Do not know.....5 Other (specify).....6	
13	Did you hear anything about iodized salt	Yes.....1 No.....2	If no go to Qns 15
14	Source of information about iodized salt	Radio.....1 Television.....2 Friends/relatives.....3 Health workers.....4 Other (specify).....6	
15	Lack of iodine can cause goiter (enlarged goiter).	Yes.....1 No.....2	
16	Iodine deficiency can expose children to mental retardation?	Yes.....1 No.....2	
17	Iodine deficiency can lead to growth retardation?	Yes.....1 No.....2	
18	Do you believe that every salt contains iodine?	Yes.....1 No.....2	
19	Iodine content reduces when iodized salt is not stored in enclosed containers?	Yes.....1 No.....2	
20	Taste of iodized salt is different from that of common salt?	Yes.....1 No.....2	
ATTITUDE			
21	Opinion on salt preference	Packed salt.....1 Unpacked salt.....2	
22	Which factors do you consider when choosing salt?	Price.....1 Brand.....2 Packaging.....3	If the ans is 4,

		Iodized.....4 Non-Iodized.....5 Other.....6 If other specify.....7	go to Qns 23
PRACTICES			
23	Duration of use of iodized salt	Less than 5 years.....1 From 6-10 years.....2 From 11-15 years.....3 16 years and above.....4 Cannot remember.....5	
24	Addition of salt in cooking during	Beginning1 Middle.....2 At the end of cooking.....3	
25	What type of salt do you use?	Course.....1 Granular.....2 Fine.....3	
26	Usually bought salt from	Local shop in the same town....1 Shop in the nearby town.....2 From the wholesale shop3 From weekly market.....4	
27	Brand names of salt used by respondents	
28	Type of container used to store salt at the food premise (<i>Observe where salt is stored</i>)	Container with a lid.....1 Container without a lid.....2 Polythene bag.....3 Rubber sachet.....4	
	What kind of food are you selling?	Salty snacks.....1 Sweets snacks.....2 Healthy foods.....3	
	What food are you selling most to the pupils?	Junk foods.....1 Healthy foods.....2	
	What food are you selling most to the children?	Junk foods.....1 Healthy foods.....2	
	How often do pupils needs additional salts and add foods?	Always.....1 Often.....2 Sometimes.....3 Rare/never.....4	
Part D: Twenty-Four Hours Dietary Recall (To be answered by a children)			
29	Was yesterday a cerebration or feast day where you ate unusual food?	Yes.....1 No.....2	
30	Did you feel unwell yesterday?	Yes.....1 No.....2	
31	What food or dish did you consume yesterday? (Provide with an ample time to recollect all foods and drinks consumed from morning till night the previous day. First ask them the food they had in the morning, and whether afterwards they took some snacks or drink in between continue asking until they went to bed)	

32	What time did you consume the food?	Morning..... Afternoon..... Evening..... Night.....	
33	What was the preparation method?	
34	Where did you eat the food mentioned?	Home.....1 Other (specify).....2	
35	Where did you get the food/ dish from?	Own production.....1 Purchase.....2 Gift or Aid.....3 Other (specify).....4	
36	What is the amount of food /dish intake?	Cup.....1 Table spoon.....2 Small piece.....3 Medium piece.....4 Large piece.....5 Full piece.....6 Full level plate.....7 Heaped plate.....8 Half plate.....9 Other (specify).....10	

Part E: Food Frequency Questionnaire

The table below assesses your dietary intake during the past 7 days (1 week). Just put a tick mark in the correct column about how many times you have eaten the indicated food in the past seven days. All the answers will be strictly confidential.

	Frequency							
Food item	Never	Seldom (≤ than once a month)	1-3 per month	1-2 per week	3-4 per week	Daily	Amount	Brand
(a) Cereals and cereal products								
Breakfast cereals								
Whole Bread								
White bread								
Chapati								
Other (specify).....								
Processed breakfast cereals								
Cakes								
Biscuits and cookies								
Cornflex								
Weetbix								
Pasta								
Spaghet								
Rice								
Other (specify).....								
(b) Roots and tuber								
Cooked Banana								
Boiled cassava								
Boiled sweet potatoes								
Other (specify).....								
(c) Meat, poultry and meat product								
Beef								
Goat meat								

Chicken												
Rabbit												
Sausage												
Eggs												
Fish and sea food												
Cold water fish												
Other (specify).....												
(d) Milk and milk product												
Fresh milk												
Milk powder												
Yoghurt												
Soya milk												
Ice cream												
(e) Pulses, Legumes and nuts												
Beans												
Lentils												
Green peas												
Roasted groundnuts												
(f) Fruits												
Banana												
Orange												
Mango												
Watermelon												
Avocado												
Paw paw												
Pineapple												
Apple												
Other (specify).....												
(g) Vegetables												
Cabbage												
French beans												
Amaranth												
Spinach												
Night shade												

Sweet potato leaves								
Pumpkin leaves								
Broccoli								
Cauliflower								
Other (specify).....								
(h) Sweets								
Sugar								
Honey								
Sweets (Candy)								
Chocolate								
Other (specify).....								
(i) Oils and fats								
Mayonnaise								
Margarine								
Other (specify).....								
(j) Convenience food/Junk foods								
Pizza								
Burger								
French fries								
Fried cassava								
Kachori								
Barbecue								
Other (specify...)								
(k) Drinks								
Fresh juice								
Wine								
Alcoholic beverage								
Energy drink								
Other (specify).....								

PART F: Focus Group Discussion guide questions with school aged children (6-7 years only)

TASK 1: Welcome, Introductions & Ice Breaker (10 minutes)

- Provide logistics (e.g. food/drink allowed, how the focus group will run, bathroom breaks, how long it will take, etc.). As pupils are introducing themselves, ask them to respond the following questions:
 - ✓ Age and grade level

✓ Favorite subject

TASK 2: For the Researcher- SHOW THE FOLLOWING CATEGORY OF FOODS TO THE CHILD (20 min)

Category A	Category B	Category C	Category D
Fried cassava	Sausage	Tomato paste	Cabbage
Potato chips	Samosa	Bullions	Broccoli
Kachori	Ice-cream	Bluband	Cauliflower
Spaghetti	Burgers	Royco	Spinach
Chapati	Beans	Mchuzi mix	Amaranthus
Maandazi	Fish	Margarine	Egg plant
Crisps	Milk	Vegetables	Night shade
Popcorn	Barbeque	Salt	Banana
Chips			Orange
Ugali			Mango
Rice			Watermelon

Call the children's attention. Ask.

1. Which food group (s) are you eating more often at home?
2. Which foods are you eating more often at school during break time?
3. Which foods do you like eating?
4. Why do you like such foods?
5. Where does the food that you like to eat come from?
6. How often did you add table salt on eating?
7. Have heard about iodized salt?
8. What is iodized salt and what are their importance in our body?
9. What type of salt do you use at home? (show them salt brands available)
10. What have you learnt from these activities?

Appendix 2: Survey Forms School-based

School: Code _____ Name _____ Date (dd/mm/yyyy) ____/____/____
Anthropometric measurement: Weight in (Kg) _____ Height in (cm) _____

Total number of children surveyed _____

ID #	Child Name	Age (Yrs)	Sex 1 or 2	Type Salt 1 or 2	Salt Iodine Level	Urine
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

26						
27						
28						
29						
30						

11. Keys

12. **Sex:** 1= Male

Salt: 1= Iodized salt

13. 2= Female

2 = Non iodized salt

Appendix 3: Informed Consent Form

**THE NELSON MANDELA
AFRICAN INSTITUTE OF SCIENCE AND TECHNOLOGY (NM-AIST)
SCHOOL OF LIFE SCIENCES AND BIOENGINEERING**

Direct Line: +255 272970006
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**Tengeru
P.O. Box 447
Arusha**

Website: www.nm-aist.ac.tz

CONSENT FORM

Title: “Iodine Status and Dietary Habits among Primary School Children, Kinondoni Tanzania”

This Informed Consent Form has two parts:

- Information Sheet (to share information about the study with you)
- Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form

Part I: Information Sheet

I am Mario Venance, a master student at Nelson Mandela African Institution of Science and Technology. I am doing research on the iodine content in processed foods. This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them to me or to another researcher.

What is the study about: the purpose of this research is to assess the iodine status and dietary practices among primary school children in Kinondoni municipality?

Purpose of the research: Excess intake of iodine is now becoming high in these regions; we want to find ways to stop this from happening. We believe that you can help us by telling us what you know both about iodine rich foods and salt handling practices in general. We want to learn about what people who live or work here eats and knows about iodine and why some people get it in excess.

Participant Selection: You are being invited to take part in this research because your child is between the ages that are considered to have more excess iodine intake.

What we will ask you to do: if you agree to be in this study, I will conduct a survey with you. The survey will include questions about dietary habit, collection of salt sample and measurement of body weight to your child.

Voluntary Participation: Your participation in this research is entirely voluntary. It is your choice whether to participate or not. The choice that you make will have no bearing on your job or on any work-related evaluations or reports. You may change your mind later and stop participating even if you agreed earlier.

Risks: No risk and any discomfort are anticipated for you to participate in this study

Benefits: There will be no direct benefit to you, but your participation is likely to help us find out more about how to optimize daily iodine intake in your community.

Compensation: You will not be provided any incentive to take part in the research.

Confidentiality: We will not be sharing information about you to anyone outside of the research team. The information that we collect from this research project will be kept private. Any information about you will have a number on it instead of your name. Only the researchers will know what your number is and we will lock that information up with a lock and key.

Right to Refuse or Withdraw: You do not have to take part in this research if you do not wish to do so, and choosing to participate will not affect your job or job-related evaluations in any way. You may stop participating in the interview at any time that you wish. I will give you an opportunity at the end of the interview to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

Part II: Certificate of Consent – Care giver

I have read or have been read the above considerations regarding the child's participation in the study. I have been given a chance to ask questions and the questions have been answered to my satisfaction.

I agree to this discussion.

Signature of head of household _____ Date _____

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given

freely and voluntarily.

A copy of this form has been provided to the participant.

Name of Researcher/person taking the consent_____

Signature of Researcher /person taking the consent_____

Date _____

Appendix 4: KNCHREC Ethical Clearance



Kibong'oto Infectious Diseases Hospital- Nelson Mandela African Institution of Science and Technology- Centre for Educational Development in Health, Arusha (KIDH-NM-AIST-CEDHA) -KNCHREC

RESEARCH ETHICAL CLEARANCE CERTIFICATE

Research Proposal No: KNCHREC0012

14TH MARCH 2019

**Study Title: CONTRIBUTION OF PROCESSED FOODS TO IODINE INTAKE
AMONG SCHOOL CHILDREN IN KINONDONI, TANZANIA**

**Study Area: THE NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE
AND TECHNOLOGY**

PI Name: MARIO SIBAMENYA VENANCE

Co-Investigator:


Institutions: School of Life Science and Bio-Engineering (LISBE) of
the Nelson Mandela African Institution of Science and
Technology

The Proposal has been approved by KNCHREC on 14th March 2019

1. Subject to this approval you will be required to submit your progress report to the KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children
2. Publication of your findings is subject to presentation to the KNCREC and NIMR Approval.
3. Copies of final publication should be made available to KNCHREC, National Institute of Research and Ministry of Health Community Development Gender Elderly and Children

Duration of Study Renewal: Subject to Renewal within ONE YEAR

Span From: 14th March 2019 to 13TH March 2020.


.....
Mr. Simon Njeya
Secretary
KNCHREC


Chairperson
KNCHREC

RESEARCH OUTPUTS

Published Research Paper (2020)

Venance, M. S., Martin, H. D., & Kimiywe, J. (2020). Iodine Status and Discretionary Choices Consumption Among Primary School Children, Kinondoni Tanzania. *Pediatric Health, Medicine and Therapeutics*, 11, 359.

Poster presentation

Iodine Status and Discretionary Choices Consumption among Primary School Children, Kinondoni Tanzania

Iodine Status and Discretionary Choices Consumption Among Primary School Children, Kinondoni Tanzania

This article was published in the following Dove Press journal:
Pediatric Health, Medicine and Therapeutics

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²Department of Health, Social Welfare, and Nutrition, Sikonge District Council, Sikonge, Tanzania; ³Department of Foods, Nutrition, and Dietetics, Kenyatta University, Nairobi, Kenya

Background: Tanzania is one of the countries where excessive iodine intake has been reported, to intervene, the identification of possible causes is required. This study aimed to assess iodine status and determine the critical contributors to excessive iodine intakes in schoolchildren aged 8–14 years.

Materials and Methods: A total of 288 school children were randomly selected in this school-based cross-sectional study in Kinondoni municipality, Tanzania. Household salt samples were analyzed using iodine rapid field test kit while that was collected from retailers/wholesalers by iodometric titration. Spot urine samples were collected and analyzed for iodine levels using a modified microplate method following the Sandell-Kolthoff reaction. A lifestyle questionnaire was administered to schoolchildren to assess their eating frequency of discretionary foods and salts.

Results: The mean salt iodine content was 53.94 ± 13.02 , and over 90% of household salt was iodized. Median urinary iodine concentration (UIC) was 401 $\mu\text{g/L}$ indicating excessive iodine intake, and one-third of the children had UIC $>500 \mu\text{g/L}$. Nearly all school children consume discretionary choices as snacks or part of a meal. Potato chips and fried cassava were the top two discretionary choices consumed with discretionary salt use (67.3%). Potato chips (adjusted odds ratio [AOR=9.04, 95% CI: 3.61–22.63]), fried cassava (AOR=11.08, 95% CI: 3.45–35.54) and groundnuts consumption for 4–7 days/week (AOR = 0.30 95% CI: 0.09–1.0) were significantly associated with iodine intake.

Conclusion and Recommendation: The evidence of excessive iodine intakes observed in previous studies and in this study should alert the policymakers to consider adjustment of the amount of iodine added to salt along with the obligation of reducing discretionary foods and salt intake.

Keywords: excessive iodine intake, discretionary choices, urinary iodine concentration, school children, salt iodization

Introduction

Iodine malnutrition is the leading cause of preventable brain damage. Its deficiency or excess intake affects the normal function of the thyroid gland.^{1–3} The thyroid gland is necessary for the production of thyroid hormone needed for healthy brain development. Impaired function of these hormones in fetal life causes maternal hypothyroidism, which has cognitive and neurological consequences for the fetus, importantly severe and permanent brain damage.⁴ Nearly 37% of the world's School-Aged Children and almost 2 billion people are affected.⁵ In Tanzania, 25% of school-aged children are at risk of deficiency.⁶

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Universal Salt Iodization (USI) is accepted globally as a means of eliminating Iodine deficiencies among the vulnerable population (Children and pregnant women).⁷ The implementation of policies on iodine fortification is effective when monitoring systems are robust. The spatial coverage of iodized salt and the level of urinary iodine concentration among vulnerable groups are indicators for USI program evaluation. In Tanzania, median urine iodine concentration (median UIC) among vulnerable groups differs between regions and among studies: ranging from below 100 µg/L to over 400 µg/L for pregnant women.⁸ For school-aged children, 25% has a median UIC below 100 µg/L and 35% above 300 µg/L,⁶ indicating low and excess iodine intake.⁷ That trend highlights the country's lack of a regulatory framework and monitoring system.

Literature shows that both insufficient and excessive iodine intakes have adverse health effects.⁹ Because very few foods inherently contain iodine, its intake from natural food is minimal. Attention is paid to increase its intake through USI.⁷ However, unmonitored supplementation of iodine can cause high intakes of iodine through discretionary salt. It is imperative to assess habitual iodine dietary intakes, particularly in children. Children spend a lot of time in schools and tuition centers.¹⁰ They usually eat the food of their own choice away from homes. Discretionary choices (foods higher in saturated fat, added salt, and/or sugar) are usually consumed due to their addictive, highly advertised, readily available, good taste, affordable, and peer-pressured.¹⁰ Among these food groups, potato chips are mostly consumed,¹¹ where they add salt on consumption.¹² Iodine intake through these foods may be high or low, depending on whether iodized salt is used or not.

Following the nutrition transition in Tanzania,^{13–15} iodine overnutrition is accelerating^{8,16} and is well documented in Dar es Salaam, especially among children.^{6,17,18} Nonetheless, its contribution factor is undocumented. Overconsumption of discretionary choices as a result of the dietary shift has been linked with increased diet-related non-communicable diseases.¹⁹ However, there is a lack of data on the consumption of discretionary foods and daily iodine intake, specifically in countries where all salt for human and non-human consumption is mandatorily iodized. Consequently, this study aimed to assess Iodine status and discretionary choices consumption among primary school children in Kinondoni Municipality, Tanzania.

Materials and Methods

Study Design and Sampling Procedures

The study was a school-based cross-sectional study involving schoolchildren aged 8–14 years selected from high and low socio-economic groups (HSGs and LSGs) in the Kinondoni Municipality, Dar es Salaam. The municipal council planning officer provided the ward index of each ward while the list of schools was obtained from the primary school education department. A socio-economic difference between the two groups provides an opportunity to investigate their influence on the iodine status. A total of eight schools, four schools from low SES and high SES were randomly selected. Schools were chosen from each group using probability proportionate to size sampling technique.⁷ A sample size of 288 was determined based on a previous prevalence of insufficient iodine intake of 25% found in school-aged children.⁶ The estimate generated was based on a marginal error of 5% and a confidence interval of 95%.

Data Collection

Enrolment and data collection were done between May and August 2019. The trained research team visited the ward education officer of the five selected wards before the school visit to provide preliminary information about the study. The ward education officers introduced the researchers to the school headteachers and other teachers. The aim and the schedule of the activities were discussed with all teachers to ensure collaboration in recruiting children. Questionnaires with both open-ended and closed questions were used to collect demographic information and discretionary food intake. Pre-testing of the questionnaire was conducted in one school other than the participating schools. The questionnaires were modified accordingly.

Dietary Assessment

In the more extensive study, we evaluated the dietary practices along with Knowledge, Attitude, and Practices using modified dietary assessment methods and specific iodine deficiency-related questionnaires, respectively, recommended by FAO.^{20,21} A single 24 hours dietary recall (24HR) and the qualitative Food Frequency Questionnaire were used. In the present study, the eating habits questionnaire was primarily developed and applied in a pilot test to check for inconsistencies and evaluate protocols for applicability and data entry. Validation was

not performed because questions were dealt with separately and aimed at categorizing groups. Children were provided with a list of commonly discretionary choices to indicate the frequency of consumption over the last seven days. The eating frequencies were finally grouped into: never, 1–3, and 4–7 days/week. Real food and pictures were used to decrease the variations between the interviewer and interviewee.²²

Anthropometric Measurements

Anthropometric measurements were conducted following standard procedures.²³ Bodyweight was taken using a SECATM electronic scale with a precision of 0.1 kg while the height was measured using SHORRTM two pieces height board at the nearest 0.1 cm. The weight of participants was measured with light clothing and without shoes. BMI for age was calculated using WHO Athro plus, whereby children with BMI \geq 95th percentile for age and sex were classified as obese, between 85th and 95th percentile as overweight and those between 5th and 85th percentile as healthy weight.²⁴

Salt Collection and Salt Iodine Analysis

Salt samples were collected from pupil's homes and in retail stores for iodine analysis. Every participating child brought two teaspoons of salt from home in a clean airtight plastic bag provided by the research team. Each salt sample from children was measured qualitatively for iodine levels using a rapid field-tests kit (MBI KITS).⁷ The kits contain a stabilized starch-based solution. A drop of the solution dripped on a white tile of salt, and the color chart was used to classify the salt iodine levels and expressed in ppm (sufficient \geq 15 ppm, medium <15 ppm, and no iodine 0 ppm).⁷ Qualitative iodine analysis using iodometric titration was employed to salt samples collected from food vendors and retail/wholesale stores according to standard procedures.⁷

Urine Collection and Urinary Iodine Analysis

The urine sample was collected and handled, as proposed by Delange et al,²⁵ Each child provided 15–20 mL of spot urine in a sterile, iodine-free 40 mL plastic universal urine container. An aliquot of urine (10 mL) was transferred to a plastic falcon tube with the child's serial number, date, and school name. The sample was then stored in a cool box at 4 °C and finally transported to Tanzania Food and Nutrition Centre (TFNC) and stored at –20 °C before analysis. UIC was analyzed by a modified microplate

method following Sandell-Kolthoff (S-K) reaction.²⁶ Both internal and external quality control materials were used covering high, medium, and low iodine concentration run between and within assays.

Data Processing and Analysis

Analysis of data was done using SPSS version 23.²⁷ Descriptive statistics were tabulated as numbers and proportions for categorical variables, continuous variables as mean and standard deviation, or as the median and percentile. Both parametric and non-parametric tests were used in testing hypotheses. For continuous variables, Independent Samples *t*-Test were used, while for the non-parametric test Mann–Whitney *U*-test and Kruskal–Wallis test were used. The Kolmogorov–Smirnov test tested normality assumptions of how the variables are distributed. A Chi-square test was used in testing hypotheses for categorical variables. Iodine status within a group was compared using median UIC as per WHO recommendation. The logistic regression model was used to evaluate factors associated with excess iodine intake (UIC >300 µg/L). Excess iodine intake was used in all models as the dependent variable, while independent variables were as tabulated. The Hosmer–Lemeshow statistic was used to test the goodness of fit of the model. Results are classified as odds ratios (OR) at 95% confidence intervals. Statistically significant differences were set at $p < 0.05$.

Results

Sample Characteristics of Respondents

The study enrolled a total of 288 schoolchildren in the age group of 8–14 years old. Two hundred sixty-six participants provided their urine and household salt sample, making a participation rate of 92.4%. The characteristics of the sample by socio-economic groups are in Table 1. The entire population included 47.7% ($n = 127$) girls and 52.3% ($n = 139$) boys. Gender, Age group, and BMI had no significant differences with socio-economic groups. However, the iodine level of household salt and age had a significant difference between the two groups, $p = 0.001$ and 0.015, respectively. The mean salt iodine content was 53.94 ± 13.02 ranging from 29.6 ppm to 71.9 ppm.

Urinary Iodine Concentrations

Iodine Status by School Socio-Economic Groups

The World Health Organization classify a median UIC of < 100 µg/L, as insufficient intake, 100–199 µg/L, as

Table 1 Sample Characteristics of Respondents

Variables	Total	HSGs	LSGs	P value
All (n)	266	113	153	
Gender				
Boys (n; %)	139;52.3	59;52.2	80;52.3	0.805 ^a
Girls (n; %)	127;47.7	54;47.8	73;47.7	
Iodine level of household salt (ppm; %)				
≥ 15	224; 84.2	106;47.3	118;52.7	0.001 ^a
< 15	37; 13.9	6;16.2	31; 83.8	
0	5; 1.9	1; 20	4; 80	
Weight (kg; mean ± SD)	36.36 ± 8.30	36.02 ± 9.26	36.60 ± 7.74	0.580 ^b
Height (cm; mean ± SD)	143.63±8.85	143.03 ± 9.38	144.07 ± 8.45	0.343 ^b
BMI (kg/m ² ; mean ± SD)	17.46 ± 2.82	17.40 ± 2.99	17.51 ± 2.69	0.743 ^b
Age (year; mean ± SD)	12.09;1.18	11.89 ± 1.26	12.24 ± 1.09	0.015 ^b
UIC (µg/L; median (P25; 75))	401.25 (296.45; 540.55)	420.9 (296.0; 77.6)	389.6 (295.15; 52)	0.754 ^b
S.I. for Food vendors and shops salt (ppm; mean ± SD)	53.94 ± 13.02			

Notes: ^aChi-square; ^bIndependent Samples t-Test.

Abbreviations: HSGs, high socio-economic groups; LSGs, low socioeconomic groups; UIC, urinary iodine concentration; S.I, salt iodine.

adequate intake, 200–299 µg/L, as more than adequate and ≥ 300 µg/L as excess intake. The results show that the median UIC was 401 µg/L, indicating excessive iodine intake. The median UIC between the two groups had no significant differences, ranging from 420.6 µg/L in HSGs to 389.6 µg/L in LSGs. Based on the UIC category, the proportion of children with UIC above 300 µg/L was 73.7%. Furthermore, only 1% of the population had insufficient iodine intake (Figure 1).

Iodine Status by Demographic and Anthropometric Data

Table 2 illustrates the association between iodine status with demographic and anthropometric variables. The median UIC in girls was significantly lower than in boys (386.0 vs

414.48 µg/L, respectively); ($P = 0.04$). Consequently, the percentage of the participants with UIC ≥ 300 µg/L was lower in girls than in boys (45.4% vs 54.6%), respectively. Based on WHO cut off points for excessive iodine intake, results indicate that 73.8% of the children ≤ 12 years old had an intake above 300 µg/L. Overweight and obese children had a higher level of UIC than their counterparts (Table 2).

Urinary Iodine Concentration and Dietary Iodine Intake

Potato chips, fried cassava, kachori, and groundnuts had a significant association with iodine status. Evaluation of the effect of chips consumption on UIC indicates that 46.5% of the children who never consumed chips in the previous week had UIC < 300 µg/L. This cluster corresponds to 32.3% of the population. In comparison, 46.5% of children in this group who never eat potato chips and only 20.2% of children who eat at least once a week had UIC < 300 µg/L ($p < 0.001$) [Table 3].

As anticipated, the risk of having UIC > 300 µg/L were significantly associated with chips and fried cassava consumption. The odds of having UIC > 300 µg/L increases with the number of frequencies of consumption. Compared to those who never consume potato chips, those who consumed for 1–3 days/week have 5.07 times higher odds (OR=5.07; 95% CI (2.32 to 11.1); $p < 0.001$) while those consumed for 4–7 days/week have 8.51 times higher odds (OR=8.51; 95% CI (3.3 to 21.99; $p < 0.001$) to be having UIC > 300. For fried cassava, those who consume

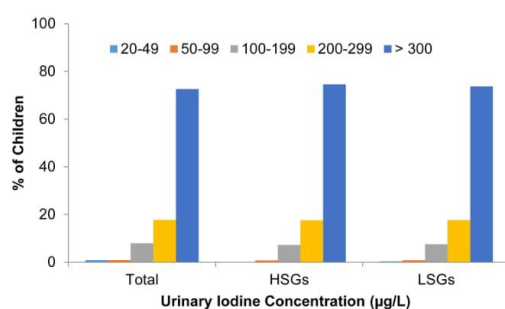


Figure 1 Urinary iodine concentration among Schoolchildren based on WHO Classification for Iodine Adequacy.

Table 2 Socio-Demographic, Anthropometric and Urinary Iodine Status of Children

Variables	UIC (µg/L)				P value	UIC < 300 µg/L		UIC ≥ 300 µg/L		P value
	n	P25	Median	P75		n	%	n	%	
Gender										
Boys	139	310.10	414.80	594.10	0.04 ^a	32	23	107	77	0.202 ^c
Girls	127	281.20	386.00	522.00		38	29.9	89	70.1	
Age category										
≤ 12 years old	168	298.50	394.45	529.50	0.545 ^a	44	26.2	124	73.8	0.952 ^c
> 12 years old	98	283.38	429.70	542.00		26	26.5	72	73.5	
BMI category										
Underweight	40	271.93	406.20	516.50	0.680 ^b	13	32.5	27	67.5	0.537 ^c
Normal BMI	201	296.00	397.80	497.23		53	26.4	148	73.6	
Overweight	18	316.75	397.30	497.23		3	16.7	15	83.3	
Obese	7	318.50	409.10	484.10		1	14.3	6	85.7	
Iodine level of household salt (ppm)										
≥ 15	224	298.50	406.55	540.45	0.537 ^b	58	25.9	166	74.1	0.774 ^c
< 15	37	287.25	359.80	569.90		10	27.0	27	73	
0	5	255.85	362.60	443.60		2	40.0	3	60	

Notes: ^aMann-Whitneys; ^bKruskal-Wallis; ^cChi-square.

for 4–7 days/week has 8.82 times higher odds than non-consumers (OR = 8.82; 95% CI (2.658–29.286); $p < 0.001$). Also, children who add table salt on consumption have 1.8 times higher odds to be having UIC > 300 than those not usually add table salt OR = 1.83; 95% CI (1.04–3.22); $p = 0.036$) [Table 4].

Discussion

The study evaluated schoolchildren's iodine status with their dietary intake in Dar es Salaam, Tanzania, between May 2019 and August 2019. The median UIC was 401 µg/L, suggesting excess iodine consumption in this population group based on WHO criteria. While in 2013, Kinondoni had a median UIC of 388 µg/L,¹⁷ the present study indicates an increase to 401.0 µg/L, and only 1.1% has insufficient iodine intake (UIC < 100 µg/L). Besides, the last published Tanzania national iodine survey by Assey et al,⁶ the median UIC was 203.6 µg/L indicating more than adequate. Albeit, in recent years, the prevalence of excess intake of iodine in this population might have been increased. The study by Assey et al,⁶ also reports that 35% of school-aged children had UIC > 300 µg/L, which differs significantly, with 73.7% in this study.

Previously, Total Goiter Prevalence was higher in the lower socio-economic status.^{28,29} In our study, the location of the school in different socio-economic status areas had no impact on iodine status. However, as expected, the

median UIC is higher in high socio-economic status than their counterpart. The reason could be that people with poor socio-economic status may use non-iodized salt as they find it cheaper and more efficient than iodized salt. Results in this study are consistent with other studies when comparing iodine status by sex; girls had lower iodine status compared to boys.³⁰ As noted by Johner et al, this might be attributed to a lower intake of energy by girls.³¹

Over the past few decades, iodine deficiency control has made remarkable progress across Africa. Sustaining this success, however, continue to be a significant challenge as it needs close cooperation among partners at various levels and active monitoring with small-scale salt producers.^{32–34} In some countries where the fortification of iodine is mandatory, the incidence of excessive iodine consumption among school-aged children has increased.^{6,17,35,36} This increase is significant and needs strengthening of monitoring systems in Iodine Deficiency control programs, such as adjusting iodine concentration in fortified salt.

School feeding program not only improves learning abilities and children attendance but also help to control the quality and type of food given to children. The majority (71.4%) of the primary schools studied had no school-feeding program. Thus pupils depend on food prepared by food vendors.³⁷ The findings regarding the type of food sold show that the majority sell fried food such as potato

Table 3 Dietary Habits and Urinary Iodine Status

Variables		UIC (µg/L)					P value	UIC < 300 µg/L		UIC ≥ 300 µg/L		P value
		n	%	P25	Median	P75		n	%	n	%	
Chips	Never	86	32.3	231.2	320.3	424.1	0.000 ^a	40	46.5	46	53.5	p<0.001 ^c
	1–3 days/week	104	39.1	230.9	397.6	526.4		21	20.2	83	79.8	
	4–7 days/week	76	28.6	390.2	528.9	706.6		9	11.8	67	88.2	
Fried cassava	Never	109	41.0	237.5	339.5	436.1	0.000 ^a	47	43.1	62	56.9	p<0.001 ^c
	1–3 days/week	103	38.7	326.8	429.3	531.1		18	17.5	85	82.5	
	4–7 days/week	54	20.3	374.9	522.5	925.25		5	9.3	49	90.7	
Kachori	Never	164	61.7	272.1	364.7	495.4	0.000 ^a	51	31.1	113	68.9	0.043 ^c
	1–3 days/week	68	25.6	311.6	461.2	613.4		15	22.1	53	77.9	
	4–7 days/week	34	12.8	370.1	463.5	686.0		4	11.8	30	88.2	
Bread	Never	146	54.9	293.7	387.7	556.6	0.759 ^a	41	28.1	105	71.9	0.573 ^c
	1–3 days/week	84	31.6	287.8	410.9	522.3		22	26.2	62	73.8	
	4–7 days/week	36	13.5	328.5	414.6	518.5		7	19.4	29	80.6	
Groundnuts	Never	167	62.8	313.3	406.1	535.7	0.668 ^a	36	21.6	131	78.4	0.059 ^c
	1–3 days/week	79	29.7	264.9	387.7	545.0		26	32.9	53	67.1	
	4–7 days/week	20	7.5	243.0	400.6	583.8		8	40.0	12	60.0	
Popcorn	Never	223	83.8	301.5	407.0	535.7	0.465 ^a	54	24.2	169	75.8	0.206 ^b
	1–3 days/week	38	14.3	246.5	329.5	576.4		14	36.8	24	63.2	
	4–7 days/week	5	1.9	254.0	351.0	650.8		2	40.0	3	60.0	
Bagia	Never	223	83.8	298.2	394.6	531.1	0.021 ^c	58	26.0	165	74.0	0.562 ^c
	1–3 days/week	31	11.7	284.3	416.6	522.0		10	32.3	21	67.7	
	4–7 days/week	12	4.5	482.5	630.0	917.6		2	16.7	10	83.3	
Ice cream	Never	149	56.0	305.8	404.4	561.4	0.885 ^a	34	22.8	115	77.2	0.300 ^c
	1–3 days/week	88	33.1	291.9	404.4	519.7		26	29.5	62	70.5	
	4–7 days/week	29	10.9	237.3	396.1	688.7		10	34.5	19	65.5	
Samosa	Never	137	51.5	298.8	401.4	557.95	0.088 ^a	35	25.5	102	74.5	0.284 ^b
	1–3 days/week	90	33.8	268.9	374.1	487.3		28	31.1	62	68.9	
	4–7 days/week	39	14.7	330.4	441.8	605.8		7	17.9	32	82.1	
Usually, add table salt	No	87	32.7	235.0	406.1	595.1	0.434 ^b	30	34.5	57	65.5	0.035 ^c
	Yes	179	67.3	314.4	401.1	526.7		40	22.3	139	77.7	

Notes: ^aKruskal–Wallis; ^bMann–Whitneys; ^cChi-square.

chips and fried cassava (data not shown). The exposure to this type of food could lead to child obesity, which in this study found that 6.8% and 2.6% of the children were overweight and obese, respectively. More importantly, these foods rely on table salt addition.¹² This practice of adding raw salt to food may expose children to excessive iodine intake, especially if the salt is over iodized.

Excess iodine consumption is associated with an increased risk of hyperthyroidism and autoimmune thyroid disorders, although, in most cases, the body can tolerate.⁹ In people with present or past thyroid disorders, only small changes in iodine intake may trigger thyroid disorders.³⁸

Generally, in countries previously identified as iodine insufficient like Tanzania, iodine consumption is recommended not to exceed 500 µg/day.⁷ Nonetheless, it is understood that the benefits of avoiding the consequences of iodine deficiency overshadow the side effects of slightly excessive iodine intake.³⁹ While this may be of concern in Tanzania because about one-third of the population studied had UIC > 500 µg/L, it is crucial to monitor this population in the upcoming iodine deficiency monitoring and control program.

The percentage of households using any iodized salt in our study was 98.1%, but among these, 85.3% were using

Table 4 Logistic Regression Models for the Relation Between UIC > 300 µg/L and Frequency of Consumption of Various Food Products

Variables		Crude OR (95% CI)	Adjusted OR (95% CI)
Chips	Never	1.00	
	1–3 days/week	3.44 (1.81–6.51) **	5.12 (2.41–10.87) **
	4–7 days/week	6.47 (2.87–14.62)	9.04 (3.61–22.63) **
Fried cassava	Never	1.00	1.00
	1–3 days/week	3.58 (1.90–6.75) **	4.87 (2.36–10.05) **
	4–7 days/week	7.43 (2.75–20.10)	11.08 (3.45–35.54) **
Kachori	Never	1.00	
	1–3 days/week	1.60 (0.82–3.09) *	
	4–7 days/week	3.39 (1.13–10.11)	
Bread	Never	1.00	
	1–3 days/week	1.10 (0.60–2.02)	
	4–7 days/week	1.62 (0.66–3.98)	
Groundnuts	Never	1.00	1.00
	1–3 days/week	0.56 (0.39–1.02)	0.54 (0.26–1.11)
	4–7 days/week	0.41 (0.16–1.09)	0.30 (0.09–1.00) **
Popcorn	Never	1.00	
	1–3 days/week	0.55 (0.27–1.13)	
	4–7 days/week	0.48 (0.08–2.94)	
Bagia	Never	1.00	
	1–3 days/week	0.74 (0.33–1.66)	
	4–7 days/week	1.76 (0.37–8.26)	
Ice cream	Never	1.00	1.00
	1–3 days/week	0.71 (0.39–1.28)	0.62 (0.31–1.25)
	4–7 days/week	0.56 (0.24–1.32)	0.37 (0.12–1.15)
Samosa	Never	1.00	1.00
	1–3 days/week	0.76 (0.42–1.37)	0.54 (0.26–1.1)
	4–7 days/week	1.57 (0.67–3.87)	1.28 (0.44–3.79)
Usually, add table salt	No	1.00	
	Yes	1.83 (1.04–3.22) *	

Notes: **Statistically significant at p value <0.01 and *Statistically significant at p value <0.05.

Abbreviations: COR, crude odds ratio; AOR, adjusted odds ratio; C.I., confidence interval.

adequate iodized salt (15+ ppm), corresponding to 84.2% of the whole population. Furthermore, findings suggest that the use of iodized salt in this population is close to 90% household coverage, as recommended by WHO.

Attaining adequate iodine nutrition in a community that consumes 10 g of salt per day, 20–40 ppm of iodine is recommended at the production level.⁷ However, the existing regulation on salt iodization in Tanzania is 40–80 ppm and 25–70 ppm at production and point of sales, respectively.⁴⁰ With the current nutrition transition, coupled with the high consumption of discretionary foods, improved market chains, and salt handling practices, users are likely to be exposed to excess iodine intake. Our study further noticed that the mean

iodine content of the selected commonly used salt brands by food vendors and households at the point of sales was above 25–40 ppm as required by WHO, indicating over iodization.

This shows that, if discretionary salt intake is high, then people are likely to have excess iodine intake. Interventions are required to reduce excessive iodine through the reduction of iodine concentration added to salt during the iodization process, like in Kenya and Brazil.^{41,42}

In our study, the importance of potato chips and fried cassava consumption to the excessive iodine intake in schoolchildren was evident. The odds of most frequently consuming potato chips were 8.5 times higher compared to those who never consumed. Inherently, potatoes and

cassava do not contain much iodine enough to causes excess intake.⁴³ Thus, the excess consumption may be caused by discretionary salt added to this food when consumed.¹² Although the study did not quantify the amount of sodium/iodine in these foods, a previous study by Lobanco et al, indicated that the sodium content of potato chips is 62.3 mg/100g,⁴⁴ and contribute to more than 2% of salt intake in children.¹² Exposure to this food on a daily bases could lead to excess iodine intake. Because reducing the population intake of discretionary choices will be very challenging, interventions aiming at reducing salt intake through discretionary foods should also go along with adjustment of the iodine content of salt during the iodization process.

Limitations of the Study

The study applied a laboratory-based approach to testing the urinary iodine and salt samples collected from food vendors and retail/wholesalers. Nevertheless, the study did not quantify the amount of iodine consumed through discretionary foods and salts. Also, the dietary assessment method used was qualitative and relied on self-reports hence may not reflect precisely the habitual dietary intake. Future studies in Tanzania should thus focus on both qualitative and quantitative dietary assessment along with household per capita salt intake, the use of iodized salt in processed foods, and the iodine content of the commonly consumed discretionary choices.

Conclusion

Iodine levels added to salt in Tanzania remained constant since 2010 despite the nutrition transitions that exist. The evidence of excessive iodine intakes in a population observed in previous studies, and this study should alert the policymakers to consider adjustment of the amount of iodine added to salt. High intakes of iodine in this population are likely due to a combination of both salt iodine concentrations above acceptable levels and excessive consumption of salt through discretionary choices. Since there is no single policy solution, a range of interventions will be needed to ensure optimum iodine intake. Adjusting the current iodine level added to salt, regularly monitoring of iodine nutrition in vulnerable groups, along with an effort to reduce discretionary foods and salt intake, is necessary to ensure optimal iodine intake.

Data Sharing Statement

The dataset which supports the conclusions of this article are available upon request.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. The proposal was reviewed and approved by The Northern Tanzania Health Research Ethics (Certificate number KNCHEC0012), and the research permit was sought from the Municipal primary education officer and school headteachers. Parents/legal guardians were given all detailed information about the study by their children one day before data collection, together with consent forms to complete if they agreed to their child's participation. The signed informed, voluntary, and written consent forms were collected from each of the participating children before commencing the data collection. Children whose parents/legal guardians decline to consent to their child's participation in the study were excluded. Each participating child assented verbally. All participants were notified of possible risks, benefits, anonymity, and the right to withdraw from the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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Poster Presentation



IODINE STATUS AND DIETARY HABITS AMONG PRIMARY SCHOOL CHILDREN IN KINONDONI, TANZANIA

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Abstract

The study was initiated to assess the possible causes of excess iodine intake in Dar es Salaam, Tanzania. The study reveals multiple possible reasons which may contribute excess iodine intake. These include discretionary choices, and high salt intake, salt handling practices as well as knowledge and attitude of iodized salt utilization.

Background

Iodine malnutrition is the global leading cause of preventable brain damage. Iodine deficiency or excess affects the normal function of the thyroid gland associated with the healthy brain development. Tanzania is one of the countries where excessive iodine intake has been reported; hence intervention and identification of possible causes is required. The present study assessed iodine status and determined the critical contributors to excessive iodine intake in school children from Kinondoni, Tanzania.

Results

Discretionary salt use (67.3%), higher consumption of potato chips (53.5%) and fried cassava (59.0%) were associated with a higher risk of excessive iodine intake. Potato chips (Adjusted Odds Ratio [AOR] =9.04, 95% CI: 3.61-22.63) and fried cassava consumption for 4-7 days/week (AOR=11.08, 95% CI: 3.45-35.54) were significantly associated with excessive iodine intake.

Conclusion

Discretionary salt intake significantly contributes to the high iodine status of schoolchildren in the study area. This effect can be reduced by public health campaigns to decrease salt consumption and improve salt iodation practices.

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