IODINE STATUS AND RISK FACTORS FOR IODINE DEFICIENCY, AMONG PRIMARY SCHOOL CHILDREN IN MT. ELGON SUB-COUNTY, BUNGOMA COUNTY, KENYA

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Iodine Status and Risk Factors for Iodine Deficiency, Among Primary School Children in Mt. Elgon Sub-County, Bungoma County, Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

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This thesis has been submitted for examination with our approval as the University Supervisors.

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DEDICATION

This work is dedicated to my family, for giving me strong financial and emotional support that motivated me to pursue this study.

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ACRONYMS AND ABBREVIATIONS

µg	Micrograms
FAO	Food and Agriculture organization
ICCIDD	International Council for Control of Iodine Deficiency Disorders
ID	Iodine deficient
IDD	Iodine Deficiency Disorder
IQ	Intelligence Quotient
MIT	Monoiodotyrosine
mUIC	Median Urinary Iodine Concentration
RDI	Recommended Dietary Intake
SAC	School-aged Children
SCN	Thiocyanate
T3	Tri-iodothyronine
T4	Thyroxine
Tg	Thyrogobulin
TSH	Thyroid stimulating hormone
UIC	Urinary Iodine Concentration
UNICEF	United Nations International Children’s Emergency Fund
W.H.O	World Health Organization

DEFINATION OF OPERATIONAL TERMS

Deficiency Occurs when intake falls below recommended levels (WHO, 2007).

Goitrogens Substance found in specific foods and inhibits iodine absorption in the body (Agrawal et al., 2018).

Hypothyroidism Low level of thyroid hormones in the blood (Zimmerman, 2012)

Iodine An anionic element that occurs naturally in the environment (Menon & Skeaff, 2017).

Iodine deficiency (ID) Occurs when iodine intake falls below recommended levels (WHO, 2007).

Iodine deficiency disorders (IDD) refer to all of the consequences of iodine deficiency in a population (Baldini et al., 2021).

Micronutrient Are vitamins and minerals needed by the body in very small amounts (Rohner, 2014).

Risk Factor A variable associated with an increased risk of disease or infection or characteristics at the biological, psychological, family, community, or cultural level that precede and are associated with a higher likelihood of negative outcomes (http://www.samhsa.gov/ebp-resource-center)

Universal salt iodization (USI) Addition (iodization) of iodine in all human salt (WHO, 2007).

ABSTRACT

Iodine deficiency (ID) is a global health problem. Approximately 2 billion people globally are at risk of ID disorder which is leading cause of preventable brain damage. Mental impairment arising from deficiency may affect children's learning capacity, quality of life, and economic productivity. In addition, increased risk to clinical conditions. A cross-sectional design utilizing multi-stage sampling was employed to determine iodine status and risk factor for deficiency among school-going-children (SAC). A total of 362 spot urine samples were collected from SAC who also provided (336) salt samples from their homes. Additionally, 53 water samples from domestic sources and 38 salt samples from distribution points were obtained. Ethical standards were upheld throughout the study. A questionnaire was administered to parents/guardians of SAC to assess social-demographic-characteristics and frequency of consuming foods from different food groups and antinutrients (goitrogens). Spot urine samples were analyzed using Sandell Kolthoff reaction and finding interpreted as median urinary iodine concentration (UIC) based on World Health Organization (WHO) recommendation and cut-offs to determine iodine status. A median 200.7µg/l was obtained which fall within the iodine nutrition adequacy region (100-299µg/l) deeming the population iodine sufficient. However, 24% of SAC reported UIC <100µg/l which fall within the insufficient levels. Similarly, iodine levels in water was determined using Sandell Kolthoff reaction and WHO cut-offs. No iodine was detected in the samples. This can imply that iodized salt is the only source of iodine to this population. Salt iodine levels were determined using iodometric titration. Although, all the samples indicated iodine presence a notable proportion were not iodized as recommended (50-84mg/Kg): about 50% of household (HH) and 36% from distribution level. Salt dampening reported in the question can be attributed to the notable proportion of HH salt with iodine levels below standard while poor iodization or packaging can be attributed to the findings at distribution levels. A fairly adequate dietary diversity was observed within the population with high consumption of foods rich in antinutrients-goitrogens. However, the impact of goitrogens seems to be minimal since the population status is adequate. High proportion of poorly iodized salt, losses due to dampening, lack of alternative sources and effects of antinutrients might be contributing to deficiencies observed. More effort is required to ensure salt iodization is as recommended coupled with continuous monitoring of the intervention to assess the impact.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Iodine is an anionic `element that occurs naturally in the environment in the form of iodide (Menon & Skeaff, 2017). It is an important micronutrient that plays a key role in the thyroid hormone production and functioning (Rohner, 2014), (Baldini et al., 2021). The main physiological role of iodine nutrient in the human body is the synthesis of thyroid hormones by the thyroid gland (Chung, 2014). Thyroid hormone is essential for normal physical and mental functioning and the development of the human body (Pagnin et al., 2021), (Ciekure & Siksna, 2017).

The United Nation Children fund (UNICEF), International Council for the Control of Iodine Deficiency Disorders Global Network (ICCIDD) and the World Health Organization (WHO) recommend daily intake of iodine for different population groups as follows: 90 µg for preschool children (0 to 59 months); 120 µg for school-children (6 to 12 years); 150 µg for adolescents (above 12 years) and adults and 250 µg for pregnant and lactating women (World Health Organization; WHO, 2007).

The main risk factor for iodine deficiency (ID) is living in a region with a low iodine nutrient concentration in the soil and water (Hailu et al., 2016), (Kapil, 2007). Moreover, the consumption of goitrogenic substances in foods like cruciferous vegetables, cassava, and millet may also account for iodide deficiency (Zimmermann, 2009). The co-existence of some micronutrients deficiencies including iron, selenium, and vitamin A can also exacerbate ID (KNMS, 2011). Chronic iodine intake below the recommended amounts results which impairs the normal functioning of the thyroid hormones (Menon and Skeaff, 2017), (Elias et al., 2021).

Effects of iodine deficiency manifests at all life stages, from the intra-uterine stage, infancy, childhood, adolescence, adulthood, and old age (Lichiardopol, 2017). During early childhood, ID interferes with brain development, causing a loss in intelligence quotient (IQ) (Levie et al., 2019). A meta-analysis of children residing in areas of high prevalence of ID indicated a lower intelligence quotient IQ of about 13.5 points on average as compared to those living in an area of adequacy (Zimmermann, 2013). Deficiency in iodine is also associated with growth retardation, cretinism, and thyroid dysfunction (Huang et al., 2016). Further, it decreases resistance to infection among children and may cause poor school performance (Hailu et al., 2016). Collectively, these consequences associated with ID are commonly referred to as iodine deficiency disorders **(Table 1)** (Iodine deficiency disorder; IDD) (Hernando et al., 2015). In general, IDD significantly affect the social-economic development of a community and the nation at large (Hailu et al., 2016). Moreover, 25% of the Disability Adjusted Life Years (DALYs) in Africa is caused by ID (Hailu et al., 2016), (Okosieme, 2006).

Table 1.1: Spectrum of Iodine Deficiency Disorder by Age Group

Physiological Group	Health Consequences of ID
Pregnant Women	Spontaneous abortions, stillbirth, and pre-term births
Fetus	Congenital anomalies, Mental deficiency
Neonates	mental deficiency, Endemic cretinism, mutism, squint, hypothyroidism and short stature and infant mortality
Child and adolescent	Impaired mental function, delayed physical development and iodine-induced hyperthyroidism.
Adults	Goiter, Iodine-induced hyperthyroidism, Impaired mental functioning, Reduced work productivity

Source: (WHO/UNICEF/ICCIDD, 2007)

Recognizing the importance of preventing and eliminating IDD, the World Health Organization and UNICEF recommended universal salt iodization (USI) as a cost-effective strategy to minimize, prevent and eliminate IDD (Hussain et al., 2019). In Kenya salt is iodized with 30-50ppm (50-84 mg/Kg) potassium iodate at the point of production.

At the end of 2016, only 19 countries were classified as iodine deficient. An estimation of over 750 million, cases of goiter has been prevented due to universal salt iodization which has also led to the protection of millions of children from preventable brain damage. However, iodine deficiency remains a public health concern with a high proportion of people at risk of deficiency. A cross sectional study on Urinary Iodine Concentration (UIC) conducted in 143 out of 194 countries in the past 15 years (2007-2022) indicated adequate status in 112 countries. However, 20 countries reported insufficient iodine nutrition status. Globally, iodine deficiency remains public health problem that require constant monitoring (IGN, 2022).

In 1994, Gitau carried out a national survey in which urinary iodine concentration and goiter were assessed in 45 districts in Kenya (Gitau et al., 1988). A goitre rate of 16% was found. Four districts had suboptimal iodine intake while two districts had excessive iodine intake. Persistence of goiter at 20% and above was demonstrated in the goiter-prone highlands districts and the less accessible arid and semi-arid districts. Between 1994 and 2004 iodine deficiency survey indicated a decrease in goiter prevalence among children aged 8-10 years from 16 percent to 6 percent respectively (Anderson et al., 2012).

Instigated by the Kenyan government a National Micronutrient Survey was conducted in 2011 (KNMS) under the leadership of the Ministry of Health with the overall objective to obtain population representative data of nutrition and micronutrient status. A range of micronutrients were assessed including iodine. During the Survey school-aged-children median urinary iodine concentration was 208µg/L (IQR: 108 - 333) which was within the range considered adequate however, 22% of SAC had UIC levels below 100µg/L (KNMS, 2011).

1.2 Statement of the Problem

Iodine deficiency is a global public health problem affecting population at all stages of life. Deficiency is leading cause of preventable brain damage and mental retardation (Zimmermann and Andersson, 2012). Mental impairment arising from iodine deficiency may affect children's learning capacity, the quality of life in a community, and economic productivity, which significantly affects the social-economic development of a nation. Furthermore, it increases the risk for clinical conditions such as congenital anomalies, cretinism, and impaired growth (Lichiardopol, 2017).

Although the household coverage of iodized salt in Kenya was high (99.9%) in 2014, the coverage for adequately iodized salt was modest at 55.9% with 29.5% of the salt being inadequately iodized and 14.6% were above the maximum recommended levels (KDHS 2014). Poor iodization of salt coupled with iodine loss during storage and cooking exposes the population to low iodine consumption which can cause iodine deficiency (WHO, 2007). Hence the need to conduct the study to determine iodine salt content and provide evidence based information for decision-making.

There is scarcity of literature showing population iodine nutrition status in Kenya. The study was critical as it provided more information on the prevalence of iodine deficiency, impact of iodization to population iodine nutrition and factors associated with the deficiency.

1.3 Justification

It is critical to monitor any health intervention to ensure it is achieving its intended goal and objective, and also to provide information needed for any corrective measure. Like any other intervention, iodization of salt requires an effective and continuous monitoring and evaluation system to ensure iodization is at required level and also meeting its intended objective of improving population iodine nutrition status (WHO, 2007).

According to the national iodine survey report goiter rates in the country had reduced but there were pockets in the country that still had high ID. For instance a sentinel survey carried out by the Ministry of Health in 2013 indicated that school-aged-children in Mt. Elgon had the highest ID at 39.3% while deficiency in the other sites ranged from 0-22.4%. In addition, data from the National Micronutrient survey of 2011indicated high (55.6%) iodine deficiency among school-going-children in Mt. Elgon region. With improved salt iodization as reported by KDHS Survey (2014) it was important to conduct the study to assess the impact of salt iodization to population iodine nutrition status.

From the study, critical information for the formulation of preventive measures and guidelines important in reducing and eliminate ID and its effect to the population was generated. Reducing or eliminating ID has the potential of reducing the disability-adjusted years (DALYs) and Years of Potential Life Lost (YPLLs). Furthermore, it contributes to the achievement of sustainable development goals (SDGs) by eradicating poverty and hunger by increasing learning ability and intellectual potential leading to better-educated citizens. It also results in a reduced burden of childcare, making resources more available in the household and providing more time for income-generating activities.

1.4 Objectives

1.4.1 General Objective

To determine iodine status and risk factors for iodine deficiency among primary school going children aged 6-12 years in Mt. Elgon Sub-County, Bungoma County, Kenya.

1.4.2 Specific Objectives

1. To determine dietary intake of school going children in Mt. Elgon.
2. To determine iodine concentration of water from the main water sources.
3. To determine iodine status of school going children (6 -12 years) using median urinary iodine estimates.
4. To determine iodine concentration of the salt at household and retail level.
5. To determine risk factors for iodine deficiency in Mt. Elgon.

1.5 Null Hypothesis

1. There is no iodine deficiency among school-aged-children in Mt. Elgon.
2. Iodine concentration in salts at household, retail and wholesale levels is not within the Kenya recommended Standards.
3. There is no significant difference in iodine concentration in water from the main sources in Mt. Elgon

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Micronutrients are vitamins and minerals that are essential for the normal growth, development, and normal health conditions of an individual (Godswill et al., 2020). Deficiency occur when there is insufficiency or lack of nutrients in the body to support normal functioning, growth, development, and immune competence (Tulchinsky, 2014). Iodine is required in the body for the production of thyroid hormone, which plays a major role in various enzymatic activities and metabolic processes (Rousset et al., 2015). For optimal development of the brain, normal levels of iodine are required. The most important period is from the second trimester of pregnancy to the third year of birth (Zimmermann, 2012).

2.2 Sources of Iodine

Ideally, most foods and beverages should naturally have iodine howover, low iodine levels in the soil and groundwater affects their iodine levels (Ershow et al., 2018). Continuous leaching from glaciations, flooding, and erosion, causes depletion of the iodide surface soil levels in most environments resulting in uneven distribution (Antonyak et al., 2018), (NIH, 2020)(Abbag et al., 2021). The leached iodide finds its way into the ocean's/sea where the water iodide concentration is approximately 50µg/litre higher than other water bodies (Xu et al., 2018), (Zimmermann, 2009). Crops grown in iodine-depleted soil will be iodine deficient and this will translate into humans and animals consuming food crops from the depleted soil (FAO, 2017). Crops from iodine-deficient soils have been found to contain a low iodine concentration of approximately 10 ppm (10µg/Kg) as compared to iodine-sufficient soils which contain approximately 1 ppm (10µg/Kg) (Eastman and Zimmermann, 2018). This is because soil and groundwater in these regions will have low iodine content.

Iodized salt is one of the main source of iodine. In addition to table iodized salt and that which is naturally available in foods and beverages, developed countries also obtain iodine from bread which is produced using iodized salt, from milk where the use of iodized salts in dairy animal feeds makes milk a good source (iodine fortification of winter cattle fodder) (Flachowsky & Franke, 2015). Iodized salt is also used in production of industrial food products, food preservation (canning), food colour (organoiodine compounds such as Erythrosine), and spices (Braverman, 2014). This increases the availability of iodine to the population (Blankenship et al., 2018), (Zimmermann, 2009). In Kenya, however, salt iodization and naturally environmental iodine are the main sources of iodine to the population. Poor salt iodization or uneven distribution in the environment thus possess a high risk of ID.

It has been established that Universal Salt Iodization (USI) is the most effective health intervention to combat ID globally (WHO, 2014). Other interventions include periodic administration of iodized capsules or iodine solutions and iodization of drinking water, wheat flour, oil and milk. The Ministry of Health (MOH) in Kenya is responsible for managing micronutrient malnutrition including iodine deficiency. All table salt used in Kenya is required by legislation to be iodized at the level of 50 to 84 milligrams of potassium iodate per kilogram of salt (equivalent to 30 to 50 milligrams of iodine per kilogram of salt and within the WHO recommended levels) according to the Food, Drugs and Chemical Substances Act Cap 254 Laws of Kenya Revised Edition 2009 (1992). To ensure conformity to Kenya salt iodization legislation, monitoring of salt iodate at both community and market level is conducted regularly.

2.3 Causes and Risk Factors for Iodine Deficiency

Poor iodization of salt and intake of salt that is not iodized can causes ID (Tayie & Jourdan, 2010). Despite, good progress being registered in regards to availability of iodized salt in Kenya, pockets of insufficiency still exists. According to the Kenya National Micronutrient Survey (2011), about a third of the household (HH) salt was iodized below the Kenyan standard, and about half was iodized according to standard

(KNMS, 2011). A similar trend was reported by Kazungu who indicated a low proportion of iodized salt in a study in the coastal region of Kenya (Kazungu et al., 2015). In 2014 KDHS, where both qualitative and quantitative determination of iodized salt was used, 99.9% of HH salts were iodized however; the coverage for adequately iodized salt was modest at 55.9%. Of all the salt samples, 29.5% had potassium iodate below the minimum permitted while 14.6% were above the maximum allowed. Non-compliance to recommended salt iodization standards and poor iodized salt levels presents a major risk factor to ID in a population. It is critical that salt producer ensure compliance to iodization standard to cater for losses that occur during production. According to WHO, 20% of iodine is believed to be lost during production, and 20% is lost through cooking and storage practices (WHO, 2007) (Bashar & Ahmed, 2016).

Iodine insufficiency in foods and beverages we consume can also result to ID: intake below the recommended dietary intake (Abbag et al., 2021). Deficiency can also result through the effects of natural or synthetic compounds known as anti-nutrients which inhibit the absorption of nutrients. Iodine absorption or utilization in the body can be inhibited by anti-nutrients known as goitrogens. Consumption of foods rich in goitrogens including cabbage, cassava, peas, beans, cauliflower, raggi, and millet can result in iodine deficiency (WHO/NMH/NHD/EPG/14.5, 2014), (Topcuoglu & Yanik, 2014), (Bouga et al., 2015).

Goitrogens act through glucosinolates, cyanogenic glucosides, thiocyanates, and flavonoids (Agrawal et al., 2018). Cruciferous vegetables like cabbage, kale, cauliflower, broccoli, turnips, and rapeseed contain glucosinolates, which compete with iodine for uptake by the thyroid (Agrawal et al., 2018). Cyanogenic glucoside is present in foods like cassava, lima beans, linseed, sorghum, and sweet potatoes and can be metabolized into thiocyanates that compete with iodine for thyroidal uptake (Eastman and Zimmermann, 2018). The flavonoid, which is found in soy and millet, may impair thyroperoxidase (TPO) activity (Goncalves et al., 2017).

Deficiency of some micronutrient including selenium, iron, and vitamin A can worsen iodine utilization resulting to deficiency (Zimmermann, 2009). In selenium deficiency, accumulated peroxidase may damage the thyroid, and deiodinase deficiency impairs thyroid hormone metabolism. An iron deficiency interferes with thyroid hormone production (Zimmermann, 2009). Iron deficiency will affect iodine absorption through thyroperoxidase, a haem enzyme that requires iron for normal functioning (Rayman, 2019). Also, nutrient competition for absorption can cause ID. Thiocyanate (SCN-) and the fluoborate ion, (BF4~) have an ionic size similar to that of iodine, thus competing with each other for absorption. This will inhibit the absorption of iodine. Cassava meal rich in cyanide (HCN) whose metabolism will yield thiocyanate will decrease the penetration of iodine into the thyroid (Cernicharo, 2011).

Age and gender can also affect iodine absorption. Research has shown that the prevalence of goitre increases with an increase in age, with the highest manifestation occurring within a decade of the life course (Malboosbaf et al., 2013). Girls have been found to have higher goitre prevalence as compared to boys of the same age (Malboosbaf et al., 2013).

2.4 Iodine Deficiency Disorders

Iodine deficiency occurs when iodine intake falls below recommended levels resulting in the inability of the thyroid gland to synthesize sufficient amounts of the thyroid hormone. This is called hypothyroidism and is the main cause of damage to the developing brain (WHO. 2007). Populations in areas of severe iodine deficiency may have intelligence quotient (IQ) of up to 13.5 points lower than that of similar populations in iodine sufficient areas (WHO, 2007). For optimal development of the brain, normal levels of iodine are required from the second trimester of pregnancy to the third year after birth (WHO, 2007). The most extreme result of hypothyroidism is cretinism (WHO, 2007). Other harmful effects of deficiency are collectively known as "iodine deficiency disorders" and affect entire populations (WHO, 2007). Apparently normal adults and children living in areas of iodine deficiency have a reduced mental ability which affects the quality of life as there is neither any ambition nor achievement (Delange, 1994). The consequences of iodine deficiency for the foetus are spontaneous abortions, stillbirths, congenital anomalies and perinatal mortality (Zimmermann, 2009). Neonates are at risk of cretinism including mental deficiency, squint, hypothyroidism, short stature and infant mortality (Zimmermann, 2009). The problems in children and adolescents include impaired mental function and delayed physical development (Zimmermann, 2009).

2.5 Vulnerable Population to Iodine Deficiency

Although people of all ages can be affected by iodine deficiency, vulnerable populations include pregnant women, lactating mothers and children between 0-12 years (WHO, 2007). Often, school-going children are the preferred group for assessing iodine nutrition of the entire population (proxy) due various reasons including ease in accessibility and the fact that they are a vulnerable group susceptible to iodine deficiency effects. There is a practical reason for not assessing very young age groups. Children 6-12 years have been recommended by the WHO for monitoring purposes as a proxy for iodine status in the population (Jennifer et al 2006). Children less than 6 years have smaller thyroid (still growing), which makes it more difficult to perform palpation. Several studies in various regions have been conducted in school-age children to estimate population iodine status, such as a scoping review in Russia to assess iodine status of children 6-12 years (Korobitsyna et al., 2022) and a United Kingdom study which assessed iodine status of school children below 14 years (Bath et al., 2016). A study conducted in China concluded that median urinary Iodine concentration of school-aged children can be used for assessing iodine nutrition in the adult population (Lie et al, 2016).

2.6 Methods to Assess Iodine Status

The recommended methods for assessment of iodine nutrition in populations are urinary iodine concentration (UI), the goitre rate, serum thyroid stimulating hormone (TSH), and serum thyroglobulin (Tg). The methods are complementary as UI is indicative of recent iodine intake in terms of days while Tg indicates an intermediate response (weeks to months). Goiter rate on the other hand shows the long-term iodine nutrition (months to years) (Zimmermann, 2008)

2.6.1 Urinary Iodine Concentration (UIC)

Urinary iodine concentration (UIC) is the most widely used method for the determination of population iodine intake based on the fact that most (about 90%) of the iodine consumed from foods and supplements is absorbed and most of it is excreted in the urine and reflects recent intake (Andersson et al., 2009). This indicator is used widely in population-based assessments of iodine status because of the easy methods for the collection and analysis of UI. Urine can be collected at any time of the day in population-based studies and only a small volume of urine is required (about 3 ml is sufficient).

2.6.2 Thyroid Size

Goiter can be measured by a) neck inspection and palpation b) ultrasound. In areas of mild ID, palpation is neither sensitive nor specific and it is therefore preferable to use ultrasound. Where there is endemic goiter, thyroid size will decrease with an increase in iodine intake. Thyroid size may however take months or even years to return to normal size after the correction of iodine deficiency. The goiter rate will be difficult to interpret during this transition period (Zimmermann, 2008).

2.6.3 Thyroid Stimulating Hormone (TSH)

In iodine deficiency, TSH levels in serum are raised because T4 concentrations are low which triggers the pituitary gland to secrete TSH. When T4 concentrations are high there is a corresponding low T4 concentration in serum. The difference in TSH serum levels in iodine deficiency and sufficiency in populations is not much and there are even overlaps in individuals. This makes it therefore impractical to use blood TSH levels in school-age children and adults for the determination of iodine deficiency (Zimmermann, 2008).

2.6.4 Thyroglobulin (Tg)

This is a thyroid protein that can be found in small amounts in all healthy individuals as it is a precursor in the manufacture of thyroid hormone (Zimmermann, 2008). In iodine deficiency, serum Tg levels are raised and reflect iodine nutrition over a period of months or years. Measurement of Tg in school age children can give indications of the iodine status of a population as well as improvements of the thyroid after repletion of iodine intake (WHO, 2007). This differs from urinary iodine concentration which is indicative of immediate iodine intake (Zimmermann, 2008). Dried whole blood spots can be used for this test and are stable for one year if stored at temperatures ≤ -20 °C. The method can be used along with urinary iodine to measure recent iodine intake (WHO, 2007).

2.6.5 Thyroid Hormone Concentrations

In iodine deficiency, T3 levels in serum either increase or remain unchanged while serum T4 levels usually decrease. Despite the changes however, the levels remain within the normal range and the overlap with levels of iodine –sufficient population make thyroid hormones unsuitable for use in the determination of ID (Zimmermann, 2008).

2.7 Global/Regional Iodine Data

Good progress has been made in addressing iodine deficiency through salt iodization. As of 2018, iodine global network estimated that 89% of the global population had access to iodized salt. Only 21 countries in the world were reported to have not achieved healthy iodine nutrition (IGN, 2018).

The United states and Canada are currently deemed iodine sufficient, however, mild deficiency are re-emerging among pregnant women over the last decade in the United States. Iodine Global Network data indicates iodine deficiency among the European population especially during pregnancy and lactation estimating that up to half of newborn are exposed to ID (IGN, 2022).

In Eastern and Southern Africa, iodine status of the population is inadequate and outdated making it difficult to estimate the prevalence of ID and addressing IDD. Iodine Global Network (IGN) data indicates good progress in ID elimination as data from 1993 to 2022 indicate notable increase in countries deemed iodine sufficient: In 1993, 113 countries in Eastern and Southern Africa had insufficient iodine status and only eight reported iodine adequacy. In 2003, 54 countries were insufficient and 67 reporting adequacy. In 2022, 111 countries reported iodine adequacy with only 19 countries reporting insufficiency (IGN, 2022).

2.7.1 Iodine Nutrition Situation in Kenya

Endemic goiter was recognized as a public health problem in Kenya in the early 1960's following which WHO 1969 that goiter be controlled (Zimmermann, 2015) Very high goiter rates of 15-72% were reported 1962-1964 the highest rates of which were in the highlands west of the Rift Valley, Nyanza and Western provinces (Gitau, 1998).

In 1970, salt iodization was started as a preventive measure for goiter. Initially, this was done on a voluntary basis at a rate of 20ppm assuming salt intake was 10g per person per day. In 1973, the level of salt iodization was increased to 30ppm after the realization that daily salt intake was about 5g (Gitau, 1998). In 1989, salt iodization was made mandatory. The standard was set at 168.5 mg/kg of potassium iodate (100ppm iodine) under the public health act Cap 242 on salt iodization in Kenya.

According to the national survey report of 2003/4, goiter rates in the country had reduced to 6%, but there were pockets in the country that had iodine deficiency. A sentinel survey by the ministry of health Kenya in 2013 indicated that school-age children in Mt. Elgon had the highest deficiency at 39.3% while deficiency in the other sites ranged from 0-22.4% (MoH, 2013). Data from the National Micronutrient Survey of 2011 indicates that iodine deficiency in Mt. Elgon was 55.6% in school-age children (KNMS, 2011).

2.8 Summary Research Gaps

It is critical to monitor any health intervention to ensure it is achieving its intended goal and objective, and also to provide information needed for any corrective measure. Like any other intervention, iodization of salt requires an effective and continuous monitoring and evaluation system to ensure iodization is at required level and also meeting its intended objective of improving population iodine nutrition status. There is however, scarcity of literature showing population iodine nutrition status, salt iodization levels and factors associated with iodine deficiency. Furthermore, the data that is available is outdated, for instance Kenya is still relying on the 2011 Kenya National Micronutrient Survey (KNMS 2011) for estimates on population iodine nutrition and salt iodization.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Site

The study was conducted in Mt. Elgon Sub-county in Bungoma County, Kenya. The study area was selected due to its geographical characteristics which has an impact on iodine distribution. Although ID can occur in different geographical areas, mountainous ranges and alluvial plain, particularly high altitude distant from the seas have a higher prevalence for deficiency. Soil erosion due to loss of vegetation from clearing for agriculture production, overgrazing, and tree-cutting can results in continued loss of iodine from the soil and ground water (WHO, 2007).

Mt. Elgon Sub-county occupies an area of 936.75 km^2. It is located on the North-Western Kenya boundary with Uganda. Mount Elgon, which is located in the Sub-county, is the fourth highest mountain in Africa and has a forest cover of 107,821 hectares (KHRC, 2014). The area experiences two rainy seasons, long and short (March to July and August to October, respectively) (KEFRI, 2017).

Figure 3.1: Map of Mt. Elgon Region Kenya (*Source: ReliefWeb)*

3.2 Study Design

The study design employed was a cross-sectional descriptive design. The research data collection was conducted between March and April 2019 in the Mt. Elgon constituency.

3.3 Study Population

The study was conducted among primary school-going children aged between 6-12 years. School-age children are preferred group for iodine surveillance because of their combined high vulnerability, easy access, and they also serve as a good proxy for the general population iodine status estimate (WHO, 2007). Healthy school-aged children who did not have a known chronic illness or had not been sick within the previous month and had resided in the region for more than one year were eligible to participate in the study Children who were suffering from severe malnutrition or those who had not resided in the area for more than 1 year were excluded from the study.

3.4 Sample Size Determination

3.4.1 Urine and Household Salt Samples

The sample size was estimated within 95 percent level of significance with an acceptable error of 5 percent using the Cochran formula of sample for proportion (Ajay & Micah, 2014) as shown below.

$$n = \frac{z^2 . p . q}{(e)^2}$$

Where:

Z = Standard variate at a given confidence level

p = Anticipated proportion with iodine deficiency
q = 1-p
e = Desired level of precision or acceptable error

$$n = \frac{(1.96)^2 . (0.5) . (0.5)}{(0.05)^2}$$

= 384.16 approximately 385

3.4.2 Water Samples Size

A minimum of 30 samples was required for water sample from different sources based on Central Limit Theorem (CLT) underlying the normal distribution, (The central limit theorem (CLT) states that the distribution of sample means approximates a normal distribution as the sample size gets larger, regardless of the population's distribution. Sample sizes equal to or greater than 30 are often considered sufficient for the CLT to hold) (Islam, 2018).

3.4.2 Distribution Levels Salt Sample Size

Sample sizes equal to or greater than 30 are often considered sufficient based on Central Limit Theorem (CT) (Islam, 2018). A minimum of 30 samples was required for salt sample at distribution level based.

3.5 Sampling Procedure

3.5.1 School-Going-Children

Mt. Elgon has four divisions (Kapsokwony, Kopsiro, Cheptais and Kaptama). To determine the number of schools to be sampled from each division, probability proportion to size was used and 13 schools were desired. Four (4) schools were proposed for Kapsokwony division and three (3) schools from each of the remaining divisions (Kopsiro, Cheptais, and Kaptama).

To select the schools in the divisions, purposive sampling was done with a view to have equal representation of males and females in the study. Since the study population age is within the Kenya primary of education grading (1-8) all the grades were included as a sampling frame except students who were below or above 6-12 years which was the age group of interest. In cases where a grade had more than one class, all the classes for the grade were combined to form one sampling unit. Probability proportion to size was then used to determine the number of student to participate from each class.

For mixed gender schools (male and female) each sampling frame (grade/class) was stratified to form male and female stratum. Systematic random sampling was then conducted to obtain same number of males and female from each stratum. For single gender schools, the neighboring opposite gender school was also involved to ensure same proportion of males and females are involved in the study.

Based on the enrollment in both schools, probability proportion to size was utilized to determine the number of pupils to be involved from the two schools and each class. Systematic random sampling was done to select the study population afterwards (**Fig 3.2**).

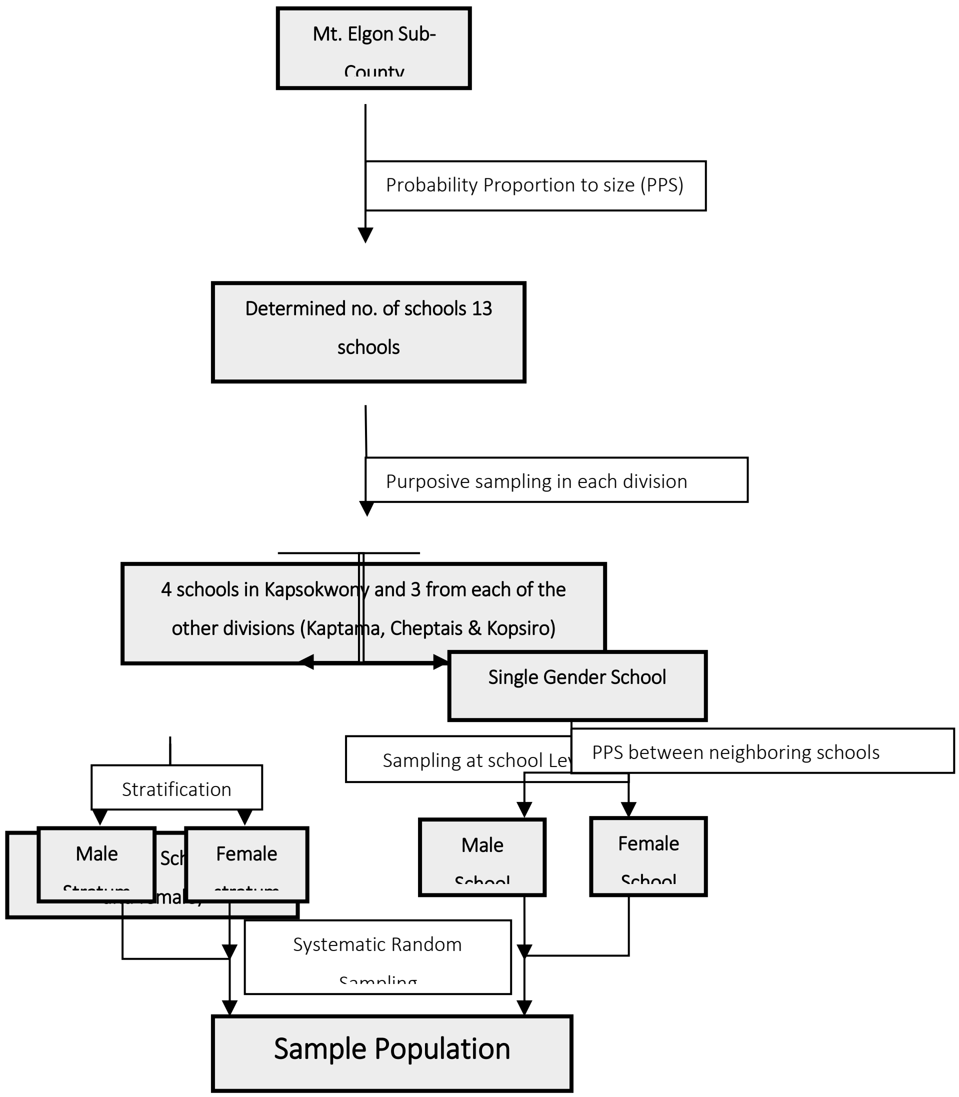

Figure 3.2: Summary Sampling Procedure of School-Aged-Children

3.5.2 Sampling Salt Samples at Distribution

In each division, majority distribution levels were identified through consultation with the division administrators. Distribution levels most utilized were selected purposively (**Fig 3.3**).

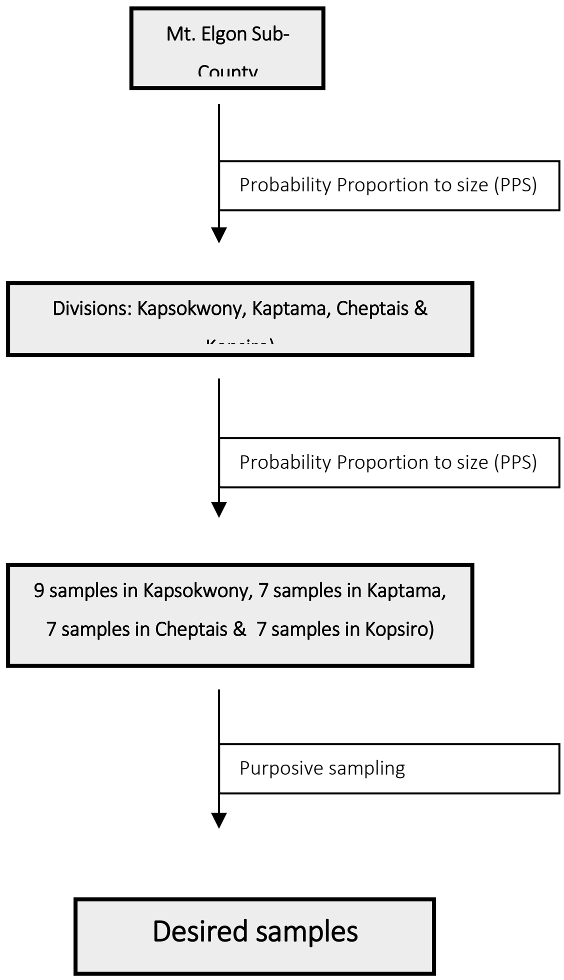

Figure 3.3: Summary Sampling Procedure of Salt Samples

3.5.3 Water from Different Sources Sampling

Sample size was determined using probability proportion to size where at least 30 samples were considered adequate. Main water sources were identified and sampling was done purposively (**Fig 3.4**).

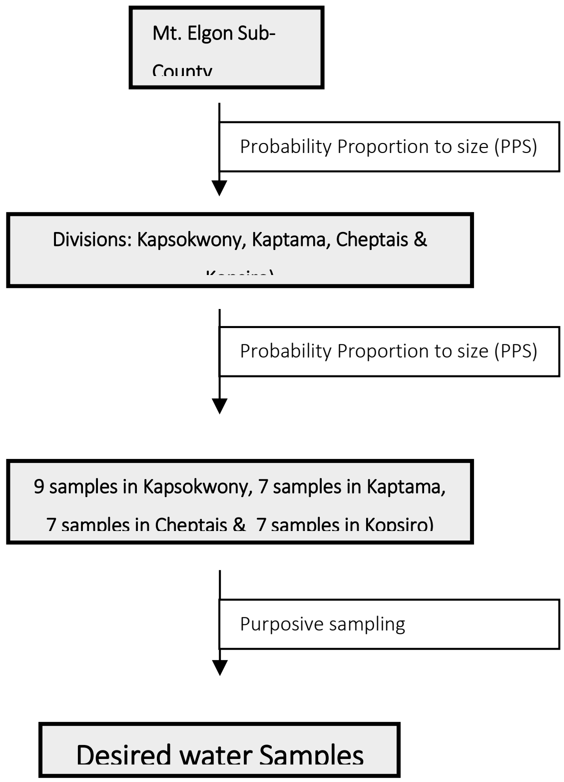

Figure 3.4: Summary Sampling Procedure of Water Samples

3.6 Data Collection

3.6.1 Questionnaire

A structured questionnaire was administered to parents/guardians of sampled school-aged-children who had given consent for their study participation sourcing information on their social demographic characteristic. In addition, a frequency questionnaire was administered to collect data on how often foods and beverages from different food groups were consumed during the past month before data collection commenced (**Appendix I**).

3.6.2 Urine Sample Collection

A sample of approximately 10 ml of urine was collected from each child who met the selection criteria and whose parents/guardians had consented to their participation. Acid-washed 15ml polypropylene plastic tubes was labeled and given to the children. The study team explained to the children how to provide the urine samples and capping it to minimize spillages. The children were also informed on contamination and how to minimize. On receiving the samples, the study team ensured the labeling was correct and the cap tightly screwed to avoid spillage, evaporation, and or contamination. The time and date of the collection were recorded. The samples were stored in cool boxes containing ice packs at an approximate temperature of -4 degrees. They were then transported within 2 hours into a portable -20 °C freezer for storage. After the fieldwork, they were transported to Kenya Medical Research Institute (KEMRI) Centre for Public Health (CPHR) laboratories for storage at -20 °c, and later analysis.

3.6.3 Salt Sample Collection

After, receiving consent from the parents/guardians and sport urine samples from the children, acid washed plastic bottles with similar identification labeling to urine samples were given to the parents/guardian for them to put approximately 10 grams of salt they use at home and the children to bring the samples to school the next day. For parents/guardians who had left, the children were explained to with a demonstration on how to collect the salt and tightly cap the container before bring the samples. A teaspoon full was used to explain the required weight of the salt (approximately 10 grams).

3.6.4 Water Samples

Water samples from different divisions were collected in 15 ml polypropylene plastic tubes from boreholes, streams, rivers, shallow and deep wells, as well as piped water (taps) in the study area. The study team collected water from different division in points serving the bigger proportion of the population. For rivers, the samples were collected near the inlet and outlet points from a division or the sub-county.

3.7 Laboratory Analysis

The analysis of salt, urine, and water iodine concentration was conducted at the Kenya Medical Research Institute (KEMRI) Centre for Public Health Research (CPHR). The center has a special laboratory dedicated to iodine analysis known as the Iodine Deficient Disorders laboratory (IDD Lab). The laboratory meets international standards for iodine analysis due to its continued certification by Centre for Diseases Control Equip programme and it is the only one of its kind in Kenya.

The principal impact indicator recommended is the population in these case school-aged-children is the median urinary iodine level as it accurately reflects current iodine intake as opposed to goitre prevalence which lags behind (WHO, 2007). Furthermore, most of the iodine absorbed in the body is released through urinary excretion (90%) (Zimmermann & Andersson, 2012). To determine iodine content in urine, Sandell-Kolthoff reaction, which is based on the reaction of iodine with ammonium persulfate is used (WHO, 2007) (**Appendix II).**

The salt iodine level was quantitatively using titration method (iodometric titration method) (WHO, 2007) (**Appendix III**). Titration method was preferred for the study because it is by far the most commonly used quantitative method, and remains the reference method for determining the iodine concentration in salt (WHO, 2007).

Due to the close structural similarities, water iodine levels were also determined using the Sandell-Kolthoff reaction. The urine, water, and salt iodine determination methods used are the WHO/UNICEF/ICCIDD approved methods (WHO, 2007).

3.8 Quality Control

Local community health promoters who have been actively engaged with health matters and have been receiving regular trainings in regard to healthcare services were recruited and trained in data collection, after which a pre-test of the questionnaire was conducted to test, evaluate and familiarize the community health promoters with the tools.

The polypropylene plastic tubes were acid-washed to ensure there were no contaminants. The urine and water samples were handled with strict caution to prevent their contact with dust or any other possible contaminant during the field collection period. Different cool boxes and freezers were used to transport and store the different samples to prevent any possible contamination. The cool box and freezer temperatures were constantly monitored using a temperature monitor chat to ensure the cold chain was maintained from transportation to storage.

During analysis to determine urinary, water, and salt iodine concentration, internal quality control materials were used; an in-house quality control material (urine sample of known values) was developed. Also, reference samples of known iodine concentrations obtained from the Centers for Disease Control EQUIP Programme (Ensuring the Quality of Iodine Procedures) were used as external reference materials for quality assurance. The control samples used were homogeneous (similar matrix) to the real samples and were used in each analytical run.

Control limits for the pool of control were calculated from the average, of the runs (at least 20 runs), mean, standard deviation mean, and an average of the daily range of the control materials.

3.9 Ethical Consideration

Approval to conduct the study was sought from the Jomo Kenyatta University Ethical review body and the National Council for Science, Technology, and Innovation (NACOSTI) (**Appendix IV**).

The intention of conducting the research was presented to both the National and County Ministry of Education, local school administration, and the concerned authorities. An official written document was presented to the authorities to seek research approval. Information about the study was explained to the local administration and school administration. Schools selected were contacted before visitation by the research to give them ample time for mobilization of parents and general facilitation.

The Jomo Kenyatta University Institutional Ethical Review Committee gave ethical approval for the study protocol (REF: JKU/2/4/896A). The National Council for Science, Technology, and Innovation (NACOSTI) granted permission for the study to be conducted in the Mt. Elgon region (REF: NACOSTI/P/18/78691). Additionally, the county and sub-county administrations granted permission for the study implementation in the region REF: BCE/DE/19/Vol.1/238 and MT.ELG/TRN/31134 respectively (**Appendix V**).

The study aim, objective, procedures, risks, benefits, and timeliness information were explained to the parents/guardians of potential participants in a lay language (simple English, Swahili, and local dialect (Sabaoti) in some instances). They were also, informed of their rights to voluntary participation and the right to refuse participation at any time without any consequences. Thereafter, informed consent was obtained. Parents/guardians who permitted their children's participation gave informed consent by signing an informed consent document. Those who were unable to sign used a thumbprint mark to consent. The children whose parents gave consent were asked for their assent to participate in the study.

Data collected was handled with the utmost confidentiality as serial numbers, rather than study participants' names, were assigned to each participant. Data collected was strictly used for the study purpose and was only accessible to research staff. The integrity, dignity, and privacy of the study participants were maintained at all-time throughout the study.

The data collection procedure had no risk to the participant. The study did not pose any adverse impact on the environment.

3.10 Data Management and Analysis

The data entry and management were done using Microsoft Office, Professional Plus Excel 2016 Software, and presented using descriptive statistics. Data was stored in soft copies and hard copies. Password protection and file restriction access were used to ensure security. Data was exported to the Statistical package for Social Science (SPSS) version 20 for univariate and bivariate statistical analysis to obtain significance levels and perform statistical tests.

The indicator measured in urine samples was urinary iodine concentration expressed in µg iodine/L. In water samples water iodine concentration was measured and expressed in µg iodine/L. Salt iodine (SI) was measured in salt from household and distribution (expressed in mg iodine/ kg). Urinary and water iodine concentration findings were reported descriptively as median values as recommended by WHO/UNICEF/IGN (WHO, 2013). The median UIC was interpreted as: < 20 µg/l (severe iodine deficiency), 20-49 µg/l (moderate deficiency), 50–99 µg/l (mild deficiency), 100–199 µg/l (adequate iodine nutrition), 200–299 µg/l (more than adequate), ≥ 300 µg/.

The salt iodine concentration findings were reported as a mean and standard deviation classification based on the Kenya Bureau of Standards recommendations (GOK, 2009). The mean potassium iodate (KIO3) concentration <50 mg/Kg inadequate, 50-84 adequate, and >84 excessive. Descriptive and inferential statistical analyses were conducted for this study. Frequencies and their respective percentages were computed for categorical variables. On the other hand, means and their standard deviations were computed for continuous variables.

The F test was used to compare the Iodine mean difference between males and females, setting a significance threshold at 0.05. Logistic regression was used to test for significant associations between dependent variables (iodine inhibitors) and subject level characteristics. The odds ratio and their respective 95% confidence intervals, as well as significance levels, were reported. All significant variables from bivariate analysis were adjusted in a Multivariable logistic regression to control for confounders and effect modifiers. Adjusted odds ratios were reported at their 95% confidence intervals as well. The significance threshold was set at 5% for all levels of statistical tests. To assess for frequency of food consumption, descriptive statistics was utilized.

CHAPTER FOUR

RESULTS

4.1 Results Introduction

To assess salt iodine content recruited school children/parents or guardians were requested to bring a teaspoon of the salt used at home. Salt was also obtained from different distribution levels (kiosk, retail, and wholesalers) in the study site. The salt was tested for the presence of iodine using iodometric titration method. Spot urine samples were collected from sampled school-going-children to determine their iodine status. Water samples were collected from different water sources in the region to determine the drinking water iodine content. A food frequency questionnaire was administered to parents/guardians of school children who consented for their children participation in the study to determine dietary intake in the region and the consumption of foods inhibiting iodine absorption (goitrogens). In addition, the questionnaire included socio-demographic, salt, and health questions in relation to iodine nutrition.

4.1.1 Response Rate

According to WHO, to reliably assess iodine status of a population at least 300 samples are required from the population (Condo et al., 2017), (WHO, 2007). The study desired a sample size of 384, but obtained 362 which represent a response rate of 94.3%. Out of the 362 SAC only 336 provided household salt samples a response rate of 92.8% (**Table 4.1**). For the questionnaire, it was desired that all the parents/guardian of SAC who provided urine samples would answer, however, due to prolonged nature and cumbersomeness of the questionnaire, more than half of the parents opted to only consented for their children participation and did not participate is responding to the questionnaire. A total of 186 parents/guardians responded to the questionnaire. For salt at distribution level and water samples, the minimum sample required (30) was achieved.

Table: 4.1: Summary Response Rate

Type	Desired Sample Size	Achieved Sample Size	Response Rate
Spot Urine Sample	384	362	94.3%
Household Salt Sample	384	336	92.8%
Distribution Salt Sample	30	38	Above 100%
Water Sample	30	53	Above 100%
Questionnaire/FFQ	**362**	**186**	**51.4**

4.2 Demographic Characteristics

4.2.1 Social Economic Characteristics of School children Parents/guardians

From the assessed population majority reported that the husband/father was the household head (82.7%). Farming was the most reported socioeconomic activity (55.9%) for the household heads. Similarly, it was reported as the main source of income in most of the households (68.3%) as shown in **Table 4.2**.

Table 4.2: Socio- Economic Characteristics of the Household

Variables	n=186	%
Household head		
Husband/Father	154	82.7
Mother/Wife	24	12.9
Grand father	5	2.7
Grand Mother	3	1.6
Occupation of Respondent		
Salaried employee	37	19.9
Farming	104	55.9
Business/self-employed	19	10.2
Casual laborer	26	14.0
Main source of income of the Respondent		
Salaried employee	33	17.7
Farming	127	68.3
Business/self-employed	14	7.5
Casual laborer	8	4.3
Other	4	2.2

4.2.2 Education Levels of the Parents/guardians

The majority of respondent (45.7%) reported primary school as the highest education level attained as shown in **Fig 4.1**.

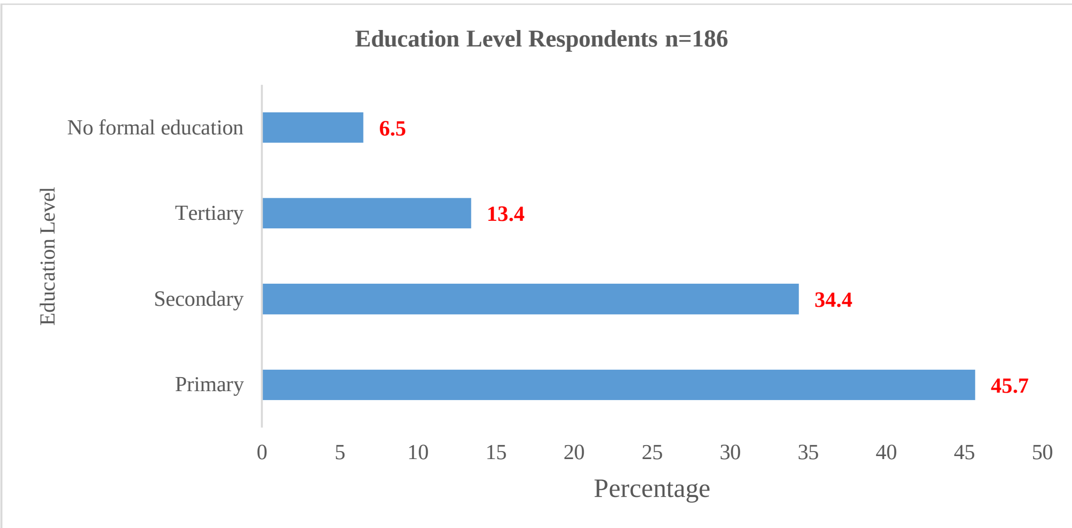

Figure 4.1: Education Characteristic of Parents/guardians

4.3 Salt Attributes

Almost half of the study respondents (parents/guardians) (45.7%) reported that they obtained the salt they use from the kiosk. Factory sealed salt was most (96.2%) preferred. Majority of the study respondents (85.0%) reported that the price of salt was the main factor they considered before purchasing salt. The majority of the respondents reported that they stored their salt in a closed container (72.0%). However, dampening of salt was reported at (40.3%) as shown in **Table 4.3**.

Table 4.3: Salt Attributes

Variables	n=186	%
Source of salt used at household		
Kiosk	85	45.7
Retail shop	73	39.2
Market	28	15.1
Salt normally used		
Sealed from factory	179	96.2
open aired salt	7	3.8
Factors considered when purchasing salt		
Price	158	85.0
Nutrition Content	9	4.8
No reason (buys available salt)	19	10.2
Who makes decision as to which salt to buy		
Self	176	94.6
Household head	10	5.4
Whether Preferred salt always available at the source		
Yes	180	96.8
No	6	3.2
How HH salt is stored		
Closed container	134	72.0
Open container	40	21.5
Other	12	6.5
Whether stored salt becomes damp		
Yes	75	40.3
No	111	59.7
Salt added to food		
Yes	186	100.0
Anyone in household advised to stop or reduce salt intake		
Yes	22	11.8
No	164	88.2

4.4 Iodine Nutrition Health Awareness

About three-quarters (75.8%) of the population who responded to the questionnaire (186) reported having seen someone in the community with neck swelling. However, only (46.2%) reported having heard about iodine with the most common source of information being radio as shown in **Table 4.4**.

Table 4.4: Iodine Nutrient and Deficiency Awareness

Variable	n=186	%
Seen anyone in the community with neck swelling		
Yes	141	75.8
No	45	24.2
Ever heard of Iodine		
Yes	86	46.2
No	100	53.8
Source of Iodine information		
Radio	172	92.5
Newspaper	8	4.3
Television	6	3.2

4.5 Iodine Concentration

4.5.1 Proportion Spot Urine Collected

A total of 362 school-going children provided spot urine samples that were analyzed for urinary iodine concentration (UIC). Although, the desired sample size was not attained, the sample obtained is sufficient based on WHO recommendation (at least 300) for obtaining a reliable population iodine status (Condo et al., 2017), (WHO, 2007). Of the 362 school-going children, 186 (51.4%) were boys and 176 (48.6%) were girls. For the boys, the highest proportion (31.2%) were aged between 6-7 years, while for the girls it was 8-9 years (33.5%) as shown in **Table 4.5**.

Table 4.5: Number of Samples Collected and Age (years) Distribution between Genders

Age	Number Males	Number Females	Percentage Male	Percentage Female
6-7	58	42	31.2	23.9
8-9	51	59	27.4	33.5
10-11	51	47	27.4	26.7
12	26	28	14.0	15.9
	N = 186	**N = 176**		

4.5.2 Median Urinary Iodine Concentration

The median urinary iodine concentration (mUIC) is the WHO-recommended indicator to assess iodine deficiency because > 90% of recent iodine intake is excreted in urine (Haldimann et al., 2015). As indicated in the **Table 4.6** the median UIC of the school-going children was 200.7µg/L, and is within the range considered adequate. The UIC values below 100µg/L were found in 24.0% of SAC, while 27.9% had UICs of 300µg/L or more. Almost half (48.1%) of the study population were within the boundaries of optimal iodine nutrition as recommended by international standards (**Fig 4.2**).

Table 4.6: School-going Children Median Urinary Iodine Concentration

Iodine (µg/l)	Classification	Number of Samples (N=362)	Percentage (%)	Iodine Status
< 20	Insufficient	2	0.6	Severe iodine deficiency
20 - 49	Insufficient	19	5.2	Moderate deficiency
50 - 99	Insufficient	66	18.2	Mild deficiency
100 - 199	Adequate	93	25.7	Adequate iodine nutrition
200 - 299	More than adequate	81	22.4	More than adequate
> 300	Excess	101	27.9	Risk of hyperthyroidism
		Median 200.7 µg/l		

Note: *The UIC results of the study presented are categorized based on Iodine global Network categorization (<100(µg/l) -Insufficient, between 100-299(µg/l) -Adequate, >300(µg/l) -Excess).*

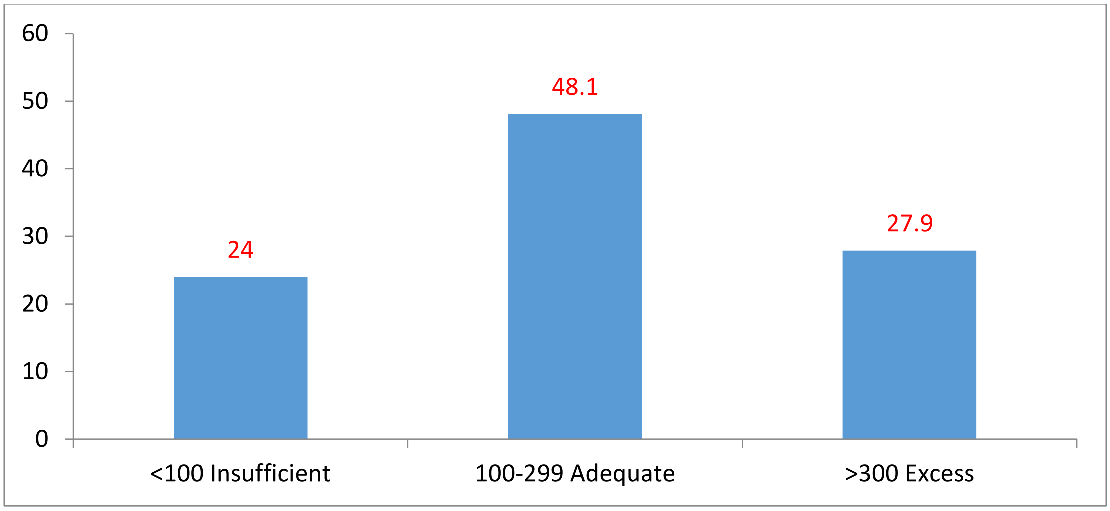

Figure 4.2: Summary SAC Median Urinary Iodine Concentration in µg/l

4.5.2.1 Median Urinary Iodine Concentration by Gender

Of the 186 samples collected from boys, 48.0% reported adequate iodine nutrition status and 23.7% having insufficient status (**Table 4.7**).

Table 4.7: Median Urinary Iodine Concentration by Boys

Iodine (µg/l)	Classification	Number of Samples (N=186)	Percentage (%)	Iodine Status
< 20	Insufficient	2	1.1	Severe iodine deficiency
20 - 40	Insufficient	9	4.8	Moderate deficiency
50 - 99	Insufficient	29	15.6	Mild deficiency
100 - 199	Adequate	46	24.7	Adequate iodine nutrition
200 - 299	More than adequate	39	21.0	More than adequate
> 300	Excess	61	32.8	Risk of hyperthyroidism
		Median 211.3µg/L		

Note: *The UIC results of the study presented are categorized based on Iodine global Network categorization (<100(µg/l) -Insufficient, between 100-299(µg/l) -Adequate, >300(µg/l) -Excess).*

More than half of the girls reported adequate iodine status with 25.8% reporting inadequate iodine status (**Table 4.8**).

Table 4.8: Median Urinary Iodine Concentration by Girls

Iodine (µg/l)	Classification	Number of Samples (N=176)	Percentage (%)	Iodine Status
< 20	Insufficient	0	0.0	Severe iodine deficiency
20 - 49	Insufficient	10	5.7	Moderate deficiency
50 - 99	Insufficient	37	21.0	Mild deficiency
100 - 199	Adequate	47	26.7	Adequate iodine nutrition
200 - 299	More than adequate	42	23.9	More than adequate
> 300	Excess	40	22.7	Risk of hyperthyroidism
		Median 188.0µg/L		

Note: The UIC results of the study presented are categorized based on Iodine global Network categorization (<100(µg/l) -Insufficient, between 100-299(µg/l) -Adequate, >300(µg/l) -Excess).

Boys had a higher median UIC (211.3 µg/l) as compared to girls (188.0 µg/l). However, the difference was not significant (*P*-value = 0.24) as shown in **Table 4.9**.

Table 4.9: Comparison Median Urinary Iodine Concentration by Gender

Iodine µg/l	Female (%)	Male (%)	Chi square	*P*-value
<100	25.8	23.7	6.75	0.24
100-299	50.9	48.0	df=5	
>300	23.4	28.4		
Median	**188.0µg/L**	**211.3µg/L**		

Note: Classification <100 Insufficient, 100-299 Sufficient, >300 excessive

4.5.3 Salt Iodine Concentration

A total of 336 school-going children provided salt samples from their households: 172 from boys and 164 from girls. Salt obtained from distribution levels that is retail shops and kiosks were 38 samples with majority being obtained from kiosk's (76.3%).

4.5.3.1 Household Salt Iodine Concentration (Potassium Iodate (KIO_3))

The Government of Kenya adopted mandatory salt iodization to provide sufficient iodine to the population. The standards for iodization were set at 30-50 mg iodine/kg salt which is equivalent to 50-84 mg/kg potassium iodate. The overall mean iodine concentration of the household salt samples obtained was 64.0 mg/Kg (SD 27.6), and was within the set standard. About half (50.6%) of the salt samples obtained were not iodized according to the set standards as shown in **Fig 4.3.**

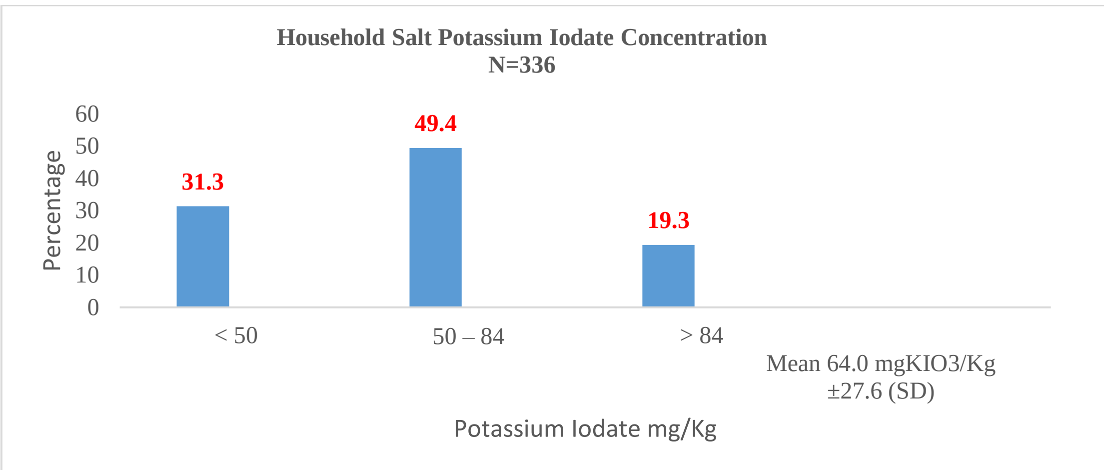

Figure 4.3: Proportion of Iodine Concentration in Household Salt Samples (%)

4.6 Salt Iodine Content of Salt from Distribution Levels

Of the salt samples from the distribution level, a mean iodine concentration of 65.0mg/Kg was obtained. Using the Kenyan Bureau classification the data indicated that more than half of the analyzed salts (63.2%) were iodized adequately and 36.6% not iodized as recommended as shown in **Table 4.10**.

Table 4.10: Iodine Concentration in Salt Samples from Distribution Outlets.

Classification mg/Kg	Number of Samples (N=38)	Percentage	Status
<50	11	28.9	Insufficient
50-84	24	63.2	Sufficient
>84	3	7.9	Excess
	Mean 65.0mg/Kg		

4.9 Water Iodine Concentration

A total of 53 water samples were obtained from different water source in the region. A high proportion of respondents (39.2%) indicated that they got water from tap water, while 29.9% indicated the river as the main source of water as shown in **Fig 4.4**. Iodine was not detected in any of the samples analyzed.

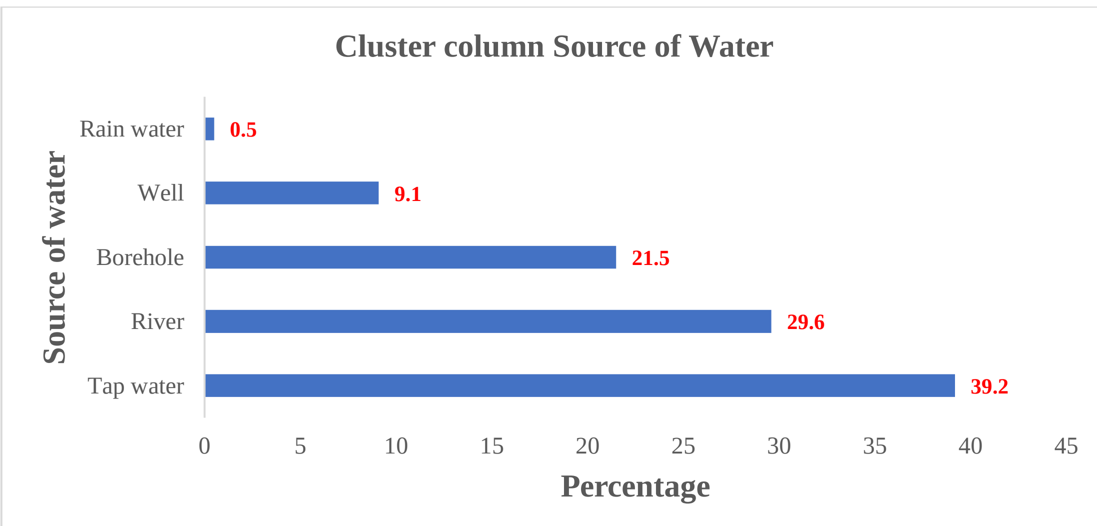

Figure 4.4: Source of Domestic Water (%)

4.10 Dietary Assessment

The dietary intake of the study population was assessed using a Food Frequency Questionnaire (FFQ). A total of seven food groups were considered: vegetables, fruits, cereals and grains, legume/nuts/seeds, roots and tubers, dairy products, and meat and meat products. The majority of study participants reported to have at least eaten one food variety from the seven food groups at the time of the interview. Overall, onions were the most consumed vegetables while for cereals and grains, corn was the most consumed. Lima beans and cowpeas were reported as the most consumed legume with Irish potatoes and sweet potatoes being the most consumed roots and tubers. For meat and meat products, beef and chicken were the most frequently consumed with fish reporting the least consumed. Unprocessed fresh milk was the most consumed dairy product in a week at 96.8% as opposed to processed milk at 25.1%.

4.10.1 Frequency of Vegetable Consumption

The foods in the group that reported a higher frequency of consumption were onions (92.5% of the population reporting consumption 5-6 times in a week). Carrots and spinach were the least consumed foods in the group at 77% and 67% of the respondents reporting never to have consumed in a week's period. Daily frequency demonstrated that majority of the foods in the group were consumed once in a day except for onions at 80.7% and tomatoes at 49.2% being consumed 2-4 times a day.

4.10.2 Fruits Consumption

Overall, there is a low proportion of fruit consumption in the region with apples being the least reported fruit consumed in a week at 95.7% followed by lemon at 92.5%. More so, of those who consumed an apple or lemon they all reported consuming the fruits once in a day. Pear's fruit and passion also reported low consumption frequency where 87.2% and 82.4% respectively, reported to have never taken fruits in that week. Bananas and avocado fruits reported higher consumption frequency in a week at 90.7% and 81.7% respectively. Of those who reported consumption of banana and avocado, majority consumed the fruit once in a day (banana 88.8% and avocado 88.1%).

4.10.3 Cereal/Grain Consumption

Ugali maize reported the highest weekly consumption frequency with 98.9% of the respondents reporting consumption. Of this population, majority (85.0%) reported consumption frequency of 5-6 times per week. Majority, reported daily consumption of ugali maize, 75.4% reporting consuming it once per day. Corn was also highly consumed with 64.2% of the respondent reporting weekly consumption. The rest of the cereals and grains reported a low consumption frequency with sorghum and millet reporting the least proportion as 92.5% and 89.3% of the respondents reporting that they did not consume the food in the week.

4.10.4 Legume/Nuts/Seeds Consumption

For legumes, lima beans had the highest consumption week's frequency at 82.4% with the majority of the respondents reporting 2-4 times consumption in a week at 45.5%. Of the proportions, majority reported consumption frequency of once per day for the same. Ground nuts were the most consumed nuts at 71.5% with the majority of the study participants reporting consumption frequency of once a week at 67.7% and once a day at 99.2%. Low seed consumption was reported in the region Sunflower seed and pumpkin seed reporting a similar proportion of non-consumption at 95.2%.

4.10.5 Roots and Tubers

Rice reported the highest frequency weekly consumption at 84.4% with the majority of the respondent reporting that they consume rice once in a week at 51.3%. Of those who reported rice consumption, majority reported that they eat rice once in a day at 91.1%. Green banana also reported a high frequency of consumption as 82.9% of study participants reporting weekly consumption. Majority, of the respondent consuming green banana 2-4 times in a week at 46.0% and 93.5% reporting that they consume it once day. Irish potatoes and sweet potatoes were also consumed in a high proportion at 81.2% and 74.3% respectively. Yams and cassava reported the lowest frequency of consumption as majority of the respondent reported that in the week they did not consume either at 89.2% and 79.6% respectively.

4.10.6 Meat and Alternative Food

On meat and alternatives offals and beef reported a higher consumption frequency at 73.3% and 72.2% respectively in a week. Insects and pork were the least consumed (never) meat and alternatives reporting 96.8% and 94.1% respectively.

4.10.7 Dairy Product Consumption

Unprocessed fresh and sour milk were most consumed in a week at 96.8% and 62.5% respectively compared to processed fresh and sour which reported a higher proportion of no consumption at 74.9% and 78.1% respectively. However, yoghurt reported the highest proportion of dairy product least consumed (never) at 84.0%. Chicken egg also reported a higher frequency of consumption at 78.0% per week with majority of the respondents reporting 2-4 times per week consumption at 38.2%.

4.11 Dietary Diversity Score

Findings from the Food Frequency Questionnaire (FFQ) were used to measure the variety of foods consumed by the population over a period of time and presented as a Dietary Diversity Score (DDS). A higher dietary diversity score was observed within the population as foods from assessed groups were consumed highly as indicated in **Table: 4.11**.

Table 4:11: Dietary Diversity Score

	Food group indicators							Dietary Diversity Score (DDS)	
	Vegetables	Fruits	Cereals	Legumes	Roots	Meat	Dairy Products	DDS (Mean ±SD)	95% CI
% Dietary Diversity N=186	99.5	98.4	97.9	100.0	99.5	98.4	94.7	6.89(±0.339)	6.8 - 6.9

Note: *High dietary =Consumed at least 4 food groups per day, Low dietary = Consumed less than 4 food groups per day*

Consumption of foods from at least four (4) food groups per day is considered high dietary diversity while consuming less than four food groups is poor diversity. As indicated in the above (**Table 4.11**), high dietary diversity was reported with the population as food eaten from more than four groups per day was reported at proportions above 90%.

4.12 Goitrogens

Glucosinolates which are present in cruciferous vegetables like cabbages and kales, and cyanogenic glucosides which are present in cassava, lima beans, sweet potatoes, and sorghum are goitrogens that inhibit iodine absorption (Pesce and Kopp, 2014). Cabbage reported a higher proportion of per week consumption at 85.0%, followed by kales at 84.5%. For cabbage, higher proportion (39.0) reported once week consumption while for kales a higher proportion (31.0%) reported 2-4 per week consumption. Soy beans, millet, and sorghum reported low frequency consumption (<12%) compared to other goitrogens containing foods as shown in **Fig 4.5.**

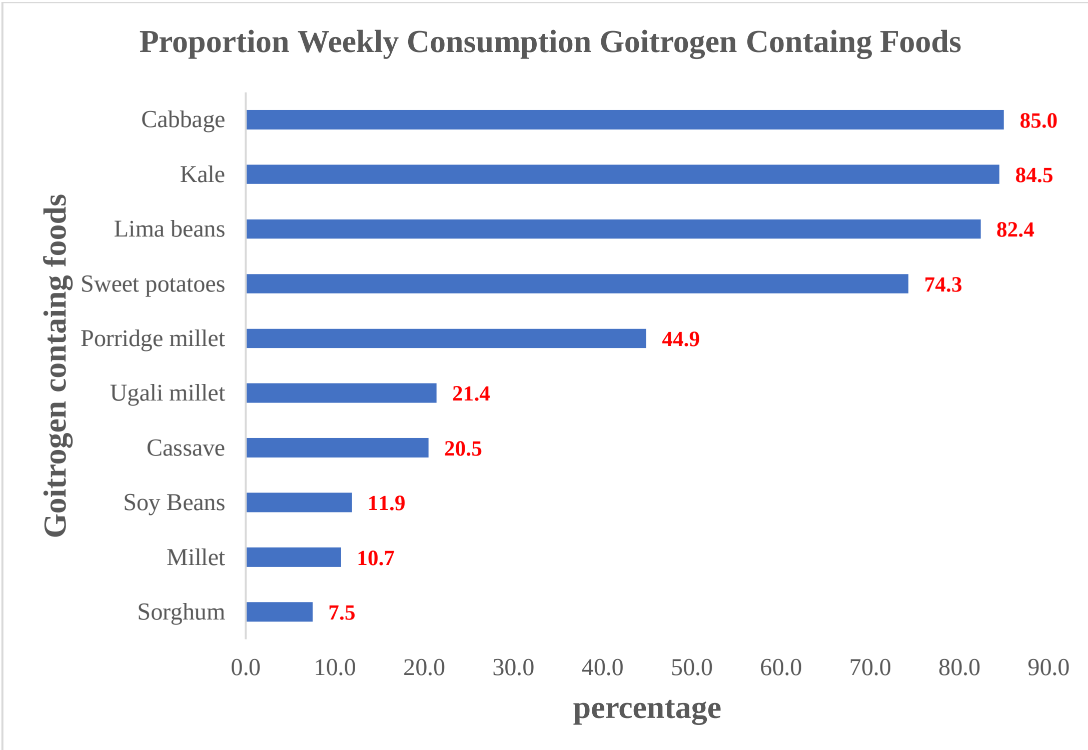

Figure 4.5: Frequency Consumption of Foods Containing Goitrogens

4.12.1 Association Goitrogens Intake and Socio-Demographic and Economic Characteristic

None of the demographic and economic characteristics was significantly associated with taking at least one of the food that are rich goitrogens (cabbage, kale, cassava, lima beans, sweet potatoes, sorghum and millet) intake 5-6 times a week, P>0.05 as shown in **Table 4.12**.

Table 4.12: Association between Taking At Least One of Goitrogens Containing Foods 5-6 Times a Week and Demographic and Economic Indicators

	Yes		No			95%CI		
Variables	**n**	**%**	**N**	**%**	**OR**	**Lower**	**Upper**	**P-Value**
Household head								
Husband/Father	64	41.6%	90	58.4%	Ref			
Mother/Wife	7	29.2%	17	70.8%	0.58	0.23	1.48	0.253
Grand father	0	0.0%	6	100.0%	UD	UD	UD	UD
Grand Mother	2	100.0%	0	0.0%	UD	UD	UD	UD
Household head occupation								
Salaried employee	17	45.9%	20	54.1%	Ref			
Farming	41	39.8%	62	60.2%	0.78	0.36	1.66	0.516
Business/self-employed	9	47.4%	10	52.6%	1.06	0.35	3.21	0.920
Casual laborer	5	19.2%	21	80.8%	0.28	0.09	0.90	0.033
Source of income								
Salaried employee	15	45.5%	18	54.5%	Ref			
Farming	49	38.6%	78	61.4%	0.75	0.35	1.63	0.474
Business/self-employed	6	42.9%	8	57.1%	0.90	0.26	3.18	0.870
Casual laborer	2	25.0%	6	75.0%	0.40	0.07	2.28	0.302
Other	1	25.0%	3	75.0%	0.40	0.04	4.26	0.448
Level of education of the household head								
Pre-primary	1	33.3%	2	66.7%	1.00	0.05	18.91	1.000
Primary	27	35.5%	49	64.5%	1.10	0.19	6.41	0.914
Secondary	29	41.4%	41	58.6%	1.41	0.24	8.25	0.700
Tertiary	14	45.2%	17	54.8%	1.65	0.26	10.36	0.595
No formal education	2	33.3%	4	66.7%	Ref			
Respondent occupation								
Salaried employee	14	50.0%	14	50.0%	Ref			
Farming	43	38.1%	70	61.9%	0.61	0.27	1.41	0.251
Business/self-employed	7	43.8%	9	56.3%	0.78	0.23	2.67	0.690
Casual laborer	4	25.0%	12	75.0%	0.33	0.09	1.29	0.111
House wife	4	33.3%	8	66.7%	0.50	0.12	2.05	0.335
Other	1	100.0%	0	0.0%	UD	UD	UD	UD
Level of education of the respondent								
Primary	33	38.8%	52	61.2%	1.27	0.35	4.55	0.714
Secondary	25	39.1%	39	60.9%	1.28	0.35	4.71	0.708
Tertiary	11	44.0%	14	56.0%	1.57	0.37	6.61	0.538
No formal education	4	33.3%	8	66.7%	Ref			

4.12.2 Association between taking goitrogens containing foods and Salt use

None of the salt usage characteristics was significantly associated with taking at least one of the goitrogens containing foods 5-6 times a week, P>0.05 (**Table 4.13**).

Table: 4.13: Association between Taking Atleast One of the Goitrogens Containing Foods 5-6 Times a Week and Salt Use

	Yes		No			95%CI		
Variables	**n**	**%**	**n**	**%**	**OR**	**Lower**	**Upper**	**P-Value**
Where salt is obtained from:								
Market	10	35.7%	18	64.3%	0.95	0.38	2.35	0.905
Kiosk	36	42.4%	49	57.6%	1.25	0.66	2.38	0.492
Retail shop	27	37.0%	46	63.0%	Ref			
Where you get water from:								
Tap water	31	42.5%	42	57.5%	Ref			
River	24	43.6%	31	56.4%	1.05	0.52	2.13	0.895
Borehole	13	32.5%	27	67.5%	0.65	0.29	1.46	0.300
Well	5	29.4%	12	70.6%	0.56	0.18	1.77	0.326
Rain water	0	0.0%	1	100.0%	UD	UD	UD	UD
Type of salt used								
Sealed from factory	72	40.2%	107	59.8%	4.04	0.48	34.25	0.201
open aired salt	1	14.3%	6	85.7%	Ref			
Consider price when purchasing salt								
Yes	60	38.0%	97	62.0%	0.66	0.30	1.45	0.299
No	14	48.3%	15	51.7%	Ref			
Consider brand when purchasing salt								
Yes	29	44.6%	36	55.4%	1.38	0.75	2.54	0.304
No	45	36.9%	76	63.1%	Ref			
Consider health when purchasing salt								
Yes	13	41.9%	18	58.1%	1.12	0.51	2.46	0.768
No	61	39.1%	94	60.9%	Ref			
Who makes decision on type of salt								
Self	67	38.1%	109	61.9%	0.41	0.11	1.51	0.179
Household head	6	60.0%	4	40.0%	Ref			
Preferred salt available								
Yes	72	39.4%	109	60.6%	0.98	0.16	5.99	0.980
No	2	40.0%	3	60.0%	Ref			
How you store salt								
Open container	15	36.1%	25	63.9%	1.70	0.30	9.65	0.552
Closed container	55	40.8%	79	59.2%	2.06	0.40	10.62	0.386
Other	4	25.0%	8	75.0%	Ref			
Is Salt dampening common in the household								
Yes	22	29.0%	51	71.0%	0.50	0.26	0.95	0.034
No	51	45.0%	62	55.0%	Ref			
Salt added cooking time								
Yes	76	39.2%	110	60.8%	UD	UD	UD	UD
Anyone in the household advised to stop salt intake								
Yes	8	36.4%	14	63.6%	0.87	0.35	2.19	0.768
No	65	39.6%	99	60.4%	Ref			

4.12.3 Association Goitrogens Intake and Selected Health and Information indicators

None of the selected health and information indicators was significantly associated with taking at least one of the 6 inhibitors of iodine intake 5-6 times a week, P>0.05 as shown in **Table 4.14**.

Table 4.14: Association between Taking atleast One of the Goitrogens Containing Foods 5-6 Times a Week And Selected Health and Information Indicators

	Yes		No			95%CI		
Variables	**n**	**%**	**n**	**%**	**OR**	**Lower**	**Upper**	**P-Value**
Know anyone with neck swelling in the community								
Yes	53	37.6%	88	62.4%	0.75	0.38	1.49	0.413
No	20	44.4%	25	55.6%	Ref			
Heard of Iodine								
Yes	35	40.7%	51	59.3%	1.12	0.62	2.02	0.707
No	38	38.0%	62	62.0%	Ref			
Got information from radio								
Yes	8	33.3%	16	66.7%	0.73	0.30	1.82	0.504
No	66	40.5%	96	59.5%	Ref			
Got information from newspaper								
Yes	3	37.5%	5	62.5%	0.91	0.21	3.94	0.903
No	71	39.7%	107	60.3%	Ref			
Got information from television								
Yes	3	50.0%	3	50.0%	1.55	0.30	7.89	0.598
No	71	39.2%	109	60.8%	Ref			

CHAPTER FIVE

DISCUSSION

The majority of the study respondents reported that they prefer purchasing sealed salt. The use of sealed salt can limit the loss of iodine providing more iodine to the population. Studies have indicated that sealed salt (packaged) have higher iodine retention (above 80%) compared to other storage methods (Jayashree et al., 2000). The stability of iodized salt which can be affected when stored in open package or open container. Sealing iodized salt is critical in reducing iodine losses (Ebisa et al., 2023). In the study, majority of the population store their salts in closed containers which further reduces iodine losses as documented by Jayashree (2000) and Shawel (2010) (Jayashree et al., 2000) (Shawel et al., 2010). However, cases of dampening of salt were reported. These can expose the salt to iodine loss posing a risk of iodine deficiency to the population as research has shown that the presence of humidity in salt can result in salt dampening which causes rapid loss of iodine from the iodized salt (WHO, 2014). The contradiction between storage in closed containers and salt dampening cannot be explained using the data obtained.

According to Kathryn (2014) increased price in foods or products can result in diminished supply and use of alternative, whose impact is poor access that put a population at risk of malnutrition (Kathryn et al., 2014). From the study the majority of the participants reported price as the driving force to the salt brand purchased as opposed to indication that the salt is iodized or health benefits. This may result to purchase of none or poorly iodized salt which can increase the risk of iodine deficiency as the population will be consuming salt that is not iodized. Furthermore, lack or poor awareness about health foods and nutrient need is a risk factor for micronutrient deficiency (Lopes et al., 2023). More than half of the study participants had poor awareness of iodine nutrient a trend that was also observed in a study in Kenya (Linda et al., 2020). Awareness about nutrient intake is an important part of well-being as it can empower the population with information that will assist them in making healthy food choices despite price disparities.

In Kenya, radio has played a significant role in providing health information to the public. This has improved in recent time as community radio stations have emerged widening coverage and elimination of language barrier. In the study, radio was reported as the main source of information. Majority, of study respondents reported that they heard or obtained information regarding iodine through radio. This correspond to a study conducted by Linda (2020) which reported radio as the main source of health information (Linda et al., 2020). There is thus a need to utilize the radio to create awareness, knowledge and other health communications to the population.

The median UIC obtained (200.7µg/l) was within a range considered internationally indicative of adequate iodine nutrition (100-299µg/l) (WHO, 2013). The population is defined to have adequate iodine nutrition because of the obtained median UIC which was above 100µg/l and more than 50% of the urine samples analyzed indicated iodine concentration above 100µg/l. Of the analyzed samples, 76% had iodine concentration above 100µg/l with only 24% reporting concentrations lower to 100µg/l. This results compares well with what was obtained during the Kenya National Micronutrient Survey of 2011 that reported adequate iodine intake in the survey (SAC median UIC was 208.0µg/) western region/province reporting a median of 164µg/l (Ministry of Health, 2011). Iodine deficiency (severe, moderate, or mild) was observed in 24% of the children. On the other hand, 28.4% of the children had excessive iodine levels (>300µg/l). The coexistence of iodine deficiency and excessive status is associated with an increased risk of thyroid disease (Du et al., 2014), (Chung, 2014). This was also observed in a study carried out in the eastern part (Makueni) of Kenya where insufficient and excess median UIC within the population was observed (Bukania, 2017).

Various literatures indicates that girls are more susceptible to micronutrient deficiency compared to boys (Shekhawat et al., 2014). For instance, a study conducted in Kyrgyzstan and Tajikistan reported a low median UIC among girl compared to boys within the same geographical area and age group (Urmatova et al., 2021), (Matthys et al., 2013). In the study, boys reported a higher median UIC as compared to girls consistent with the Kenya National micronutrient survey where the median UIC for boys was higher compared to girls (Ministry of Health, 2011). In addition, to the studies in Kyrgyzstan and Tajikistan which also found out higher nutrient adequacy in boys compared to girls. The study findings also correspond to them.

The strategy of universal salt iodization (USI) to eliminate ID has been a success in the reduction of the IDD burden (UNICEF, 2006). In Kenya, salt iodization is mandatory. The standard for iodization is set at 50-84mg/Kg of KIO_3 [13]. Study findings indicate adequate iodization of salt based on the mean obtained. However, more than half of the analyzed salts were iodized either below or above the recommended standard. According to the Kenya Demographic Household Survey Report of 2014, Kenya has almost achieved the USI goal of having more than (90% of the HH using iodized salt) however, only 47% of the salt in Bungoma County was found to be iodized within the set standards (50 - 84mg/Kg of KIO_3) with 41% of the salt not iodized to standard (KDHS, 2014). The KDHS (2014) study findings corresponds with the study findings as only, 49.4% of the analyzed salt was found to be adequately iodized and 31.3% iodized below recommended standards.

A similar trend was reported in the KNMS study where 627 household samples reported a mean of 40.8mg/kg with about 48.3% reporting adequate iodization, 29.2% inadequate and 22.5 excess iodization (Ministry of Health, 2011). Further, in a study conducted by Kazungu in the Coastal region of Kenya, inadequate and excessive salt iodization were reported (Kazungu et al., 2015).

Generally, the obtained results in this study indicates an improvement in the proportion of salts iodized according to recommended standard compared to the results obtained in the Kenya National Micronutrient Survey of 2011, where only 48.3% of household salt collected were found to be iodized as recommended (KNBS, 2011). The notable difference in the proportion of salt iodized according to the recommendation at distribution and household levels could be attributed to poor storage which results in dampening of salt and cooking processes. Iodization of salt below the recommended level can be a risk factor for iodine deficiency disorders.

Naturally, soil and groundwater should contain iodine providing the population with the nutrient (WHO, 2019). A National Survey in Somalia found high iodine concentration in drinking water samples obtained from boreholes (Kassim et al., 2014). However, no iodine was detected in the water samples obtained in our study. This could be attributed to flooding and erosions which sweep iodine into the ocean reducing the soil and groundwater iodine content hence the risk of deficiency to the population since the plants and animals consuming foods grown in this environment will not get the nutrient. The results conform with WHO 2019 report which indicated that drinking water contribution to human iodine exposure is too low to provide a significant uptake (WHO, 2019), hence the need for salt iodization.

Dietary diversity is associated with better nutritional status as no single food contains all the needed nutrient (Rah et al., 2010). Dietary diversity is critical in ensuring a balanced and healthy diet (Sanusi, 2010). Better nutrition is associated with improved infant, child, and maternal health, stronger immune systems, lower risk of non-communicable diseases, and longevity. This further, influences the quality of life improving children learning capacity for better prospects in the future life, improving productivity, economic status as funds are utilized for economic development breaking the cycle of poverty and hunger (WHO, 2000).

From the study population result, a fairly adequate dietary diversity was observed. Overall, there is a low intake of fruits in the region but high vegetable intake. This corresponds to a study by Nyanchoka et al who observed fruit and vegetable eating patterns among university students in Kenya and found that the mean intake of fruits was 1.7 serving per day which was lower than the vegetables serving at 1.9 (Nyanchoka et al., 2021). In another study among adults in Kenya, it was found that on average, the study participants had 0.78 servings of fruits a day, 1.31 servings of vegetables a day (Pengpid et al., 2015). In terms of calories, meat and alternatives, dairy products, and legumes are consumed but in lower proportions compared to cereals/grains. Literature indicates that due to culture and other factors, cereals and grains have remained the most important source of calories especially in Africa where it is estimated to contribute about 70 per cent of energy intake (Kearney, 2010).

Various studies have indicated that socio-demographic and economic characteristic have an effect on intake of goitrogens containing foods. For instance, a study conducted in Ethiopia indicated that occurrence of iodine deficiency in school-age children was significantly associated with socio-demographic and economic characteristic including parental/guardian education. However, just like in this study, the study in Ethiopia concluded that socio-demographic and economic factors did not have an impact on intake of goitrogens containing foods (Wolka et al., 2014), (Muktar et al., 2019). Research has demonstrated that provision of health information and education can improve health choices. Association between health information provision and better health choices has been demonstrated (Raghupathi et al., 2015) however, in the study, there was no significant difference observed between those with heath information and those who did not have the information.

Although salt iodization has decreased the incidence of iodine deficiency, some cases still persist which can be attributed to the consumption of foods that inhibit thyroid hormone synthesis known as goitrogens (Babiker et al., 2020). From the FFQ, it was identified that there is consumption of diets rich in goitrogens (example cabbages). However, despite the high consumption of foods containing goitrogens in the study region, the population iodine intake was found to be adequate. The findings match a study in Nairobi where no effects were observed between the population consuming foods rich in goitrogens and those who did not eat goitrogens containing foods (Kishoyian et al., 2014). These findings elucidate Zimmerman's notion that goitrogens are activated especially when iodine supply is limited (Zimmermann, 2018). From the study we have seen that the population is iodine sufficient thus a possibility that the intake of foods rich in goitrogens might not affect their iodine nutrition.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The median urinary iodine levels in the target population are above 100µg/l (200.7µg/l) and no more than 20% of values are below 50 µg/l indicative of adequate iodine nutrition according to WHO/ICCIDD/UNICEF classification. Although, 24% of the population reported inadequate iodine status (<1000 µg/l), a population can only be deemed to be iodine deficient if 20% of the population iodine status is below 50µg/l which is not the case in our study. Based on these results, the null hypothesis is accepted: there is no iodine deficiency among school-going children in the Mt. Elgon region in Kenya. However, coexistence of insufficiency and excessive median UIC exists within the population, which increases the risk of thyroid disorders and calls for further investigation.

Iodine was present in all the salt samples assessed from the household and distribution levels. However, just about half of the analyzed households' salts were iodized according to recommended standards. Based on the findings the null hypothesis is accepted: salt iodine concentration at the distribution level is not iodized according to the standards set (50 - 84 mg/Kg of KIO_3) by the Kenyan Government. It was noted that iodized salt was one of the main sources of iodine to the population with ground water not contributing to the population's iodine nutrition. In the region, different water sources are used to obtain water for domestic use with tap water and river sources being the most common sources. No iodine was detected in the water samples obtained for the study. In this case, the null hypothesis is accepted: there is no significant difference in water iodine concentration from the main water sources in the Mt. Elgon region.

There is need for continuous nutrition campaigns aimed at increasing intake of foods from different groups. Some of the foods consumed contain goitrogens but their impact on the population's iodine status seems to be minimal.

6.2 Recommendations

1. Sustained and continuous monitoring of iodized salt at factory, distributor and HH levels to ensure salt iodine fortification is at recommended levels.
2. More impact evaluation by monitoring iodine status of the population especially vulnerable groups to evaluate the impact of iodization
3. Further studies to assess the impact of salt handling and storage to inform corrective measures and guidelines.

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APPENDICES

Appendix I: Food Frequency Questionnaire

ASSESSMENT OF IODINE STATUS AND RISK FACTORS FOR DEFICIENCY AMONG PRIMARY SCHOOL CHILDREN IN MT. ELGON CONSTITUENCY, BUNGOMA COUNTY, KENYA

Name of interviewer………………………………….. Date of interview …………

Name of respondent (Guardian) ……………………Age…………Sex………………..

Name of child……………………………………Age…………..Sex………………..

School………………………….. Class……..

Religion: 1. Christian 2. Muslim 3. Others specify ……………

Ward……………………………….. Village……………………….

I would like to ask about your eating pattern over the past 1 week. Please tell me over the past 1 week did you eat each of the foods I ask you. If you did not eat any of the food over the past 1 week, we will go to the next food; if you ate more than 1 time in the past 1 week, please tell me how often you ate it and how much you eat each time. For each food there is an amount shown, either a "medium serving" or a common household unit such as a slice or teaspoon. Please put a marking **(x)** in the box to indicate how often, on average, you have eaten the specified amount of each food during the past 1 week.

If you do not have any questions, could we start now? Do not leave any lines blank.

FOODS AND AMOUNTS

VEGETABLES (medium serving)	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Spinach								
Kale (Sukuma)								
Cabbage								
Carrot								
Amaranthus(terere, mchicha, suja, kunde)								
Leaves (Beans, cassava, pumpkin								
Onion								
Tomato								
Sweet pepper(hoho)								
FRUITS (1 Fruit)	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Pears								
Banana								
Orange								
Mangoes								
Papaya								
Passion								
Lemon								
Avocado								
Melon								
Apple								
Guava								
Loquat fruit								
CEREAL/GRAIN	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Millet								
Sorghum								
Corn (maize)								
Porridge (maize)								
Porridge (Millet, wheat, sorghum)								
Ugali (maize)								
Ugali (millet)								
Wheat (chapatti, mandanzi, cake, kdf)								
LEGUME/NUTS /SEEDS	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Lima Beans								
Cow peas								

Pigeon peas								
Lentils (kamande)								
Soy beans								
Green peas(minji)								
Greengrams								
Lab lab(Njahi)								
Pea nuts								
Groundnuts								
Pumpkin seed								
Sunflower seed								
Sesame (simsim)								
ROOTS&TUBERS (medium serving)	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Sweet potatoes								
Cassava								
Irish potatoes								
Yams								
Arrow root (Nduma)								
Green banana								
Rice								
MEAT and ALTERNATIVE	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Beef								
Mutton								
Goat meat								
Chicken								
Duck								
Turkey								
Pork								
Offals (matumbo, mutura, liver)								
Insects (termites, crickets)								
Fish								
Chicken egg								
Other eggs								
DAIRY PRODUCTS	**Never**	**Once a week**	**2-4 per week**	**5-6 per week**	**Once a day**	**2-3 per a day**	**4-5 per a day**	**6+ per day**
Unprocessed milk fresh								
Unprocessed milk sour								
Processed milk fresh								
Processed milk sour								
Yoghurt								
Chicken egg								
Other egg								

Social Demographic

1. How many people live in your household?
2. Who is the head of the household?
3. What is the occupation of household head?

a) Salaried employee b) Farming c) Business/self-employed d) Casual laborer

e) Others specify

4. What is the main source of income of the household head?

a) Salaried employee b) Farming c) Business/self-employed d) Casual laborer

e) Others specify

5. What is you occupation (respondent)?

a) Salaried employee b) Farming c) Business/self-employed d) Casual laborer

e) House wife f) others specify

7. What is the education level of the Household head?

a) Pre-primary b) Primary b) Secondary d) Tertiary e) No formal education

8. What is the education level of the respondent?

a) Primary b) Secondary c) Tertiary d) No formal education

Salt

9. Where do you obtain the salt used at your household?

a) Market b) Kiosk c) Retail shop d) River bed e) others specify……………………..

10. Where do you get water for domestic use?

a) Tap water b) River c) Borehole d) Well e) Rain water

11. Which salt do you normally use?

a) Sealed from factory b) open aired salt c) Others specify

12. What factor do you consider before purchasing salt?

a) Price b) Manufacturer/brand c) Health value d) others specify…

13. Who makes decision as to which salt to buy?

a) Self b) Household head

14. Is the preferred salt always available at the source? a) Yes b) No

15. How do you store your salt?

a) Open container b) closed container c) others specify

16. Is dampening of salt common?

17. When salt become damp, how do you dry it?

18. When is salt added to food?

a) During cooking time b) end of cooking c) Individual food serving

19. Have you or anyone in your household been advised to stop or reduce salt intake?

a) Yes b) No

If YES why?

Health

20. What is the health benefit of salt

21. Have you noticed anyone in the community with neck swelling? a) Yes b) No

22. Have you ever heard of Iodine? a) Yes b) No

If 'YES' where did you get the information from?

a) Radio b) Newspaper c) Television c) others specify

Food Frequency Questionnaire (Sabaoti)

Nambeet tap sumaneet…………………..

Seesetap Kookwoonutyeetaap kaat ambu cheesok che nyigiisech mu Mt Elgon, kauntitaap Bungoma, Kenya

Chiitap ng'alaleet………………………… Besheet taap ng'alaleet………..

Chii nyee ketu tebuutook…………………………………….. Kanyishook……

Sayeet: 1. Mkristo…. Muislominteed 3. Alaak…………

District………………. Division

Location…………….

Sub- Location…………………….. Clinic nyeebo cheesok……………..

Araweet ngonyoo……..

1. Kiyaam nee beeshet ageenge nye kokeetha? Taashi amiik che kiiskiseech ako sakityeek
   Booru **ole kiiteshyi muunyet** angiikas yoo miitee kabichiinek **ako seekeekaap mwogoniik , Sukuma)**

Olee kiomee	**Bsenikap amiik ako tukuuk chi keeyee**	**Miite munyeet?**	
		Miite	**Moomi**

Amiik che yeechen		Arook che mite amiik	Arook che momii amiik
Baandek	Nasimnyaanik Baaka Ng’aanuk Mcheleek		
Tubers	Biasik Moogononik Naboorik		
Tyoongiik	Beentho Samaakit Ngokyeet Mokoik		
Ngweek	Sukuuma/ sekeekap mogoonik Kabiichineek spiinachineek Kisocheet		
Pulses	Makandeek Pinziinek Makandekap chumbek Supuutap Makandekap chumbek		
Beeko	Cheeko Muguluuk		
Maitoniik	Maitoniik		

2). Mwoweech inyoorichenee anoo munyeet nyee iyeeishee amu kaa kwaak?

1. Sookoni 2. Dukeet 3. An’ynooo 3. Maang’et 4. Mwou alaak…….

3). Inyoorchinee anoo beeko che iyee kwaak?

1. Mweenetap beeko 2. Kitaweet 3. Any’noo 4. Taaput 5. Roopta

4.) Iteeshinee beekuuk sakityeek cheebo kaa nde cheebo chumbeek?

1. Ichamchindoosi 2. Machamchindoosi ☐

5.) Sumanetap kayeyinteet

1. Primary

2. Sekondar

3. Kiikethee sekondar

6.) Isheet nye yeeye kayeyinteet

1. Isheetap koo ako kaapatisheet

2. Isheet nyee inyooru kii yooboku araweet

3. Ayeeye biashareet nyeenyu/ kyaasirkey

4. Ayeeye kibarua

5. Ayeeku chiitap Juakali

6. Amiite sukuuru

7.) Iyeeye nee nyee kooning mung'eteeet?.........................

8. Inyorchinee anoo amiik kwaak?

1. Mbareenyu

2. Sookoni

3. Duuket

9.) Iyeeyishee peesanik ataa iwanee muunyet mbuu araweet ?.............

10. Munyeet ng'onyoo nyee iwanee kwaak?

1. Nyeekikekaar mu faktoor
2. Nyeekichakeekar asiswook alaak
3. Akee

11.) Ng'onyii koonu peesanik che kyoone munyeet?

1. Chiitap kathaa

2. Mwoou alaak…………

12. Neenyu ikasee kurook manoo iwanee chumbiit?

1. Beeit

2. Oli keeyethee/ kanyieet

3. Ityeechinee nee mu bortoo

4. Mwoou alaak

13.) Ng'oo nyee amuonee kle kyoone chumbiit ngonyoo?

1. Anii ngiit

2. Chitaap kooto

14.) Tooku chumbiit nyo icheeme kwaak?

1. Achamchimdoosi 2.Maachamchimdoosi

15. Mwoweech inyoorichenee anoo munyeet nyee iyeeishee amu kaa kwaak?

1. Sookoni

2. Dukeet

3.Mwou alaak………………………..

16. Iyethoi chumbiit mbu kaa?

1. Achamchimdoosi 2.Maachamchimdoosi

Isheet akoo olee kekaneree chumbiit

17.) Ikaneree anoo chumbiit?

1. mkeebet nyebo Plaastik

2. Mkeebet nyebo kichuumet

3. Paper bag

4. Mwou alaak………………………..

18. Iwolee chumbiit nyi tya ku kwaak? (mwou kle kiloonik ataa/ peesanik atta0

………………………………………………………………

19.) Ibuure chumbiit boshoshook ataa?....................

20.) Iteshinee chumbiit oliibo amiik watyaa?

1. Yoo akwong'see
2. Yoo kawoong'u kwongseet
3. Yoo kakekomoon amiik

21.) Kikeyeetening chumbiit mbu subutaali? 1. Ichamchindoosi 2. Machamchindoosi

22.) Iyeeyishee chumbiit mbu besheet safarinook ataa?............................

23.) Araa   wechektoos oli iyeeshee chumbiit ako ole wuu koret?

1. Ichamchindoosi   2. Machamchindoosi

Appendix II: Measuring Urinary and Water Iodine Concentration Using Ammonium Persulfate Method (Sandell-Kolthoff reaction)

A3.1 Principle

Urine is digested using ammonium persulfate, the iodine present is used as a catalyst in reduction of ceric ammonium sulfate to cerous form which is detected by rate of colour change from yellow to colourless (Sand-ell-Kolthoff reaction).

A3.2 Equipment

Thermometer, Heating block (temperature range between 90-250^{o}C, Pipettes, Vortex machine, Magnetic hotplate and stirrer, Spectrophotometer, Fumed hood, Glassware (test tubes, volumetric flask, measuring cylinder, beaker, storage bottle), and Analytical balance (with readability of at least 0.001g).

A3.3 Reagents

Analytical grade chemicals to be used for preparation of solutions are;

a) Sulfuric acids (H_2SO_4)
b) Sodium hydroxide (NaOH)
c) Deionized water (H_2O)
d) Potassium iodate (KIO_3)
e) Ammonium persulfate ($H_8N_2O_8S_2$)
f) Arsenic trioxide (As_2O_3)
g) Sodium chloride (NaCl)
h) Cerric ammonium sulfate [$Ce(NH_4)_4(SO_4)_4.2H_2O$]

A3.4 Solutions

A3.4.1 Ammonium persulfate preparation (1.0 mol/l)

Dissolve 114.1 g of ammonium persulfate in 500 ml deionized water. The reagent should be stored in darkness and is stable for months. Refrigeration prevents decomposition.

A3.4.2 5N Sulfuric acid

Measure 140 ml of concentrated sulfuric acid and add slowly to 700 ml deionized water. The reaction is exothermic. Let it cool to room temperature then adjust the volume to 1 litre using deionized water.

A3.4.3 3.5N Sulfuric acid

Measure 97 ml concentrated sulfuric acid and add slowly to 700 ml deionized water the reaction is exothermic. Let it cool to room temperature then adjust the volume to 1 litre using deionized water.

A3.4.4 Sodium hydroxide (0.875 mol/l)

Weigh 17.5 g sodium hydroxide pellet and dissolve in 500 ml deionized water.

A3.4.5 Arsenious acid solution (0.025 mol/l)

Weigh 5 g arsenic trioxide and 25 g sodium chloride. Place them in a 1-L Erlenmeyer flask, slowly add 200 ml of 5N sulfuric acid and heat gently while stirring to dissolve. When the mixture dissolve, (about 15 minutes) cool to room temperature. Dilute to 1 litre using deionized water. Should be stored in darkness and is stable for months.

A3.4.6 Ceric ammonium sulfate solution (0.038 mol/l)

Weigh 24 g ceric ammonium sulfate and dissolve in 1 litre of 3.5N H_2SO_4 should be used after 24 hours. Store in darkness and is stable for months

A3.4.7 Standard solution (KIO_3)

Stock Standard A (1000 µg/ml)

Weigh 0.840 g potassium iodate and deionized water to final volume of 500 ml

Stock Standard B (10 µg/ml)

Dilute 5 ml of standard A in deionized water to make a total volume of 500 ml

Working standards

Prepared using standard B aliquoting 200, 400, 800, 1200, 2000, and 3000 µl which will be equivalent to iodine concentrations of 20, 40, 80, 120, 200, and 300 µg/l. Standard zero is pure deionized water. The standards should be stored in plastic bottles in a refrigerator and away from light. It is stable for approximately 3 months.

A3.5 Standard Operating Procedure UIC Determination

1. The urine sample should be allowed to reach room temperature
2. The urine is mixed (vortex can be used) to suspend the sediments
3. Pipette 250 µl of each urine sample, working standards (0-300 µg/l) and internal control sample. Into a 13 * 100 mm test tube. For accuracy duplicate of each sample is used.
4. 1 ml ammonium persulfate is added to each sample
5. Heat the samples for 1 hour at 91-95 ^{o}C
6. Cool the sample to room temperature (approximately 15 minutes)
7. Add 2.5 ml of arsenious acid solution mix (vortex) and let it stand for 15 minutes
8. Add 300 µl of ceric ammonium sulfate solution to each sample at a 30 second interval between successive tubes and mixing with vortex. A stopwatch should be used for this step.

9. Allow to sit for 30 minutes at room temperature after addition of ceric ammonium sulfate to the first tube.
10. Read absorbance in UV/Vis spectrometer at 420nm. Read the tubes successively at same time intervals as when addition of ceric ammonium sulfate

A3.6 Calculation of results

Construct a standard curve by plotting iodine concentration of each standard with absorbance. Log of absorbance at 420 nm is plotted on the X-axis versus standard iodine concentration in µg/l on the Y-axis. Use exel software and scatter plot to obtain the curve. The concentration of iodine in µg/l of each specimen is calculated by the equation of linear trendline. All samples with absorbance >than 300 µg/l should be diluted with a dilution ratio of 1:3 or 1:5 with water.

Appendix III: Titration Determination of Salt Iodate and Iodide Content (Iodometric Titration)

A4.1 Principle

Sulfuric acid is added to liberate free iodine from iodate in the salt sample; potassium iodate is added to solubilise the free iodine which is insoluble in pure water under normal conditions. The free iodine is then titrated with sodium thiosulfate which consumes the free iodine. The amount of sodium thiosulfate used is proportional to amount of free iodine liberated from the salt. Starch is added and functions as an external indicator reacting with free iodine producing a blue colour. The loss of the blue colour is the end-point of the reaction which will occur on further titration indicating that all the iodine has been consumed by the thiosulfate.

A4.2 Reagent preparation

A4.2.1 Sodium thiosulfate (0.005 N)

Weigh 1.24 g $Na_2S_2O_35H_2O$ and dissolve with double-distilled water to make 1000 ml. Store in a cool dark place. The reagent is stable for at least a month.

A4.2.2 Sulfuric acid (2 N)

Measure 6 ml analytical grade sulfuric acid and slowly add to 90 ml double-distilled water. The reaction is exothermic and should be left to cool to room temperature before filling to mark of 100 ml. The solution is stable for several months.

A4.2.3 Potassium iodate 10 %

Weigh 100 g KI and dissolve with about 700 ml double-distilled water fill to the mark to make 1000 ml. The reagent should be protected from direct light. When properly stored the solution is stable for 6 months.

A4.2.4 Starch indictor solution

Approximately 15-30 g of reagent-grade sodium chloride is dissolved in 100 ml double-distilled water. While stirring add sodium chloride to saturation point. Heat the mixture in a beaker until excess salt dissolve. Cool to room temperature and decant the supernatant into a clean bottle. The reagent is stable for 6-12 months.

A4.2.5 Standard operating procedure iodometric titration

1. Weigh 10 g iodated salt and dissolve in 50 ml double-distilled water
2. Add 1-2 ml sulfuric acid followed by 5 ml potassium iodide (will turn yellow in iodine presence)
3. Keep the mixture in a dark place for 5 -10 minutes for it to reach optimum reaction time
4. Titrate the mixture using sodium thiosulfate using 2 ml of starch as indirect indicator

A4.2.6 Calculation of results

Iodine (mg/kg) or ppm = Titration volume (ml) * 21.15 * normality of sodium thiosulfate * 1000/salt sample weight in g.

Appendix IV: Informed Consent Form

ASSESSMENT OF IODINE STATUS AND RISK FACTORS FOR DEFICIENCY AMONG PRIMARY SCHOOL CHILDREN IN MT. ELGON CONSTITUENCY, BUNGOMA COUNTY, KENYA.

Introduction

Iodine deficiency occurs when the intake of iodine is less than the recommended levels. Over the years, soil erosion has been taking place because of loss of vegetation due to overgrazing, cutting of trees for firewood and timber and clearing for agricultural purposes. Because of this continuous leaching of iodine, the soils in most parts of the world have lost iodine. As a result, the water available to the populations and the crops grown on the soils do not have iodine.

Lack of iodine in the body causes goiter, which causes damage to the developing brain. There are other harmful effects of lack of iodine or low iodine levels in the body, which include:

Children and adolescents:	Impaired mental function
	Delayed physical development
Neonates:	Cretinism including mental deficiency, mutism, short
	Stature and infant mortality
Foetus:	Spontaneous abortion
	Stillbirth

Iodine deficiency can be found all over the world and even in areas where goiter cannot be seen.

Iodine deficiency can be controlled by the addition of iodine to edible salt. The Government of Kenya has a law directing all salt manufacturers to add iodine to the edible salts they manufacture.

Reasons for doing the study

The aim of doing this study is to determine if the iodine intake school-age-children meets their recommended intake.

Procedures

If you give consent for your child/children to participate in this study by signing the section at the end of this form, the following activities will be undertaken:

Schoolchildren

- Children will be given a sample container to provide a urine sample.
- The children will be given a container to bring a sample of salt from their household.

Benefits

There are no immediate benefits that your child/children will get from participating in the study. Findings of the study may however lead to measures, which may benefit you and the entire community in future. By participating in the study, you child will help the Government determine if the iodine status of the population is adequate and corrective measures will be taken if necessary.

Risks and Precautions

There is practically no risk associated with the study. The collection of a urine and salt sample entails no risk. Responding to the questionnaire might be a bit tearing.

Confidentiality

Any records relating to you and your child's/children's participation will be kept strictly confidential. Response to the questions we ask will remain anonymous and will not be linked to your child's name. Your name and that of your child/children will not be used in any reports from the study and you will receive a copy of this consent form.

Participation Information

Taking part in this study for your child/children is on a voluntary basis. You may decide to withdraw your consent at any time. You may also withdraw your child from participating in the study at any time. Refusal to participate will not result in the loss of benefits that you are otherwise entitled to including school, clinics or maternity. You are welcome to ask any questions about this study before giving your consent or anytime thereafter before the start of the study or as it continues.

Contacts and further information

In the event of further questions, please contact the principal investigator, **Stephen Onteri on telephone 072176546 (P. O. Box 20458- 001, Nairobi) or Jomo Kenyatta University ERC department 067-5870001** or project staff. If you cannot reach the principal investigator or wish to talk to or contact somebody else, please call Jomo Kenyatta University of Agriculture and Technology **067-5870001**.

I the undersigned have fully understood the information above which has been explained to me by the researchers, and I voluntarily consent for my child to participate. I have had an opportunity to ask questions, all of which have been answered to my satisfaction.

Name of parent/guardian --

Name of pupil --

School --

Date-------------------------

Name of person obtaining consent-------------------------------------

Signature of person obtaining consent----------------------------------

Informed Consent Form Swahili

Fomu ya idhini

Tathmini ya hali ya lishe ya iodhini ya wanafunzi katika eneo laMt. Elgon, kata ya Bungoma, Kenya

Utangulizi

Ukosefu wa iodini hutokea iwapo kiwango cha iodini katika lishe kiko chini ya kiwango kilichopendekezwa. Kwa muda sasa, mmomonyoko wa udongo umekuwa ukiendelea kwa sababu ya kupungua kwa mimea kutokana na ulishaji wa mifugo, kukata miti kwa ajili ya kuni na mbao na kukata miti na mimea asili kwa ajili ya kilimo. Hali hii hupunguza kiwango cha iodini kwa udongo. Hivyo basi, udongo katika sehemu nyingi umepoteza iodini. Kwa hiyo, maji na mimea iliyokuzwa kwa udongo wa aina hii haina iodini. Ukosefu wa iodini mwilini husababisha uvimbe wa koo (goiter) ambao husababisha uharibifu wa ubongo unaokua. Madhara mengine ya ukosefu wa iodini au viwango vya chini vya iodini katika mwili ambayo ni:

Watoto na vijana: utenda kazi wa akili chini ya kiwango cha kawaida

huchelewesha ukuaji

Watoto walio na umri wa chini ya mwezi mmoja:

upungufu wa akili,

mutism

ufupi wa kimo,

mtoto kufa kabla ya mwaka mmoja

Mtoto ambaye hajazaliwa:

kupoteza mimba kwa kawaida

mtoto kufa angali mimbani

Ukosefu wa iodini unapatikana duniani kote na hata katika maeneo yasiyo na matukio ya uvimbe wa koo (goitre). Ukosefu wa iodini unaweza kudhibitiwa na kuongeza ya iodini kwa chumvi iliyotumika kupikia vyakula. Serikali ya Kenya ina sheria inayohitaji viwanda vyote vinanvyotengeneza chumvi kuongeza iodini kwa chumvi.

Madhumuni ya utafiti

Lengo kuu la kufanya utafiti huu ni kuchunguza kama watoto wa umri wa kuenda shule wanapata iodini ya kutosha kwa matumizi yao.

Utaratibu wa utafiti

Iwapo utatoa idhini ya mtoto wako kushiriki katika utafiti huu kwa kutia sahihi katika fomu hii, taratibu zifuatazo zitafanyika;

- Watoto watapewa chupa ya kutia sampuli na kuombwa watoe sampuli ya mkojo. Shughuli hii itafanyika shuleni.

- Watoto wataulizwa walete chumvi kidogo kutoka nyumbani
- Wanawake wataulizwa maswali kadhaa kuhusu lishe, matumizi ya chumvi, wanapopata maji ya kunywa na jinsi wanavyosafisha maji ya kunywa.

Faida

Kushiriki katika utafiti huu hautakufaidi wewe ama mtoto wako moja kwa moja. Matokeo ya utafiti yatasababisha kubuniwa kwa hatua ambazo zinaweza kukufaidi wewe na jamii nzima baadaye. Kwa kushiriki katika utafiti huu, utasaidia Serikali kuamua kama kiwango cha iodini miongoni mwa jamii umefikisha kiwango kinachohitajika. Iwapo hakijafikisha, mipango ya kudhibiti upungufu itabuniwa.

Hatari na Tahadhari

Ukusanyaji wa sampuli ya mkojo hauhusishi hatari. Unaweza kupata uchovu kidogo tunapokuuliza maswali. Huna haja ya kujibu maswali usiyojisikia kama kujibu.

Usiri

Rekodi zote kuhusu mtoto / watoto wako zitahifadhiwa kwa siri. Majibu utakayotoa kwa maswali utakayoulizwa hayataambatanishwa na majina ya mtoto wako. Jina la mtoto wako / watoto wako halitatumiwa katika ripoti yoyote itakayotokana na utafiti huu. Utapata nakala yako ya fomu hii ya idhini.

Maelezo kwa washiriki

Kushiriki kwa mtoto wako/ watoto wako katika utafiti huu ni kwa hiari yenu. Unaweza kuamua kuondoa idhini yako wakati wowote. Pia, uko na uhuru wa kumwondoa mtoto wako kushiriki katika utafiti wakati wowote. Kukataa kushiriki hakutaathiri faida ama huduma ambazo una haki ya kupata shuleni, kliniki au utakapoenda kujifungua. Jisikie huru kuuliza maswali au maelezo yoyote kuhusu utafiti huu kabla ya kutoa idhini yako au wakati wowote baada ya kuanza kwa utafiti au utakapokuwa ukiendelea.

Mawasiliano na maelezo zaidi

Iwapo utahitaji kuuliza maswali au maelezo zaidi, tafadhali wasiliana na mchunguzi mkuu, Stephen Onteri 0721765462 (P. O. Box 20458 00100, Nairobi) ama chuo kikuu cha Jomo Kenyatta kwa nambari 067 587 0001.

Taarifa ya mzazi / mlezi

Nimeelezwa kikamilifu ujumbe kuhusu utafiti huu na watafiti. Kwa hiari yangu, natoa idhini ya mtoto wangu kushiriki. Nimepewa nafasi ya kuuliza maswali,na nimeridhishwa na majibu yaliyotolewa.

Jina la mzazi / mlezi --

Jina la mwanafunzi -------------------------------------- Darasa la--

Tarehe ---

Informed Consent Form Sabaoti

FOOMUT NYEE IBOORU KACHAMIIS CHIITO

Seesetap Kookwoonutyeetaap kaat ambu cheesok che nyigiisech mu Mt Elgon, kauntitaap Bungoma, Kenya

Touneet

Rartoou chumbiit mbu bortoo yemebere kaam chiito munyeet nyo mayamee. Mbu kanyishook cho kiikubaa kiweeto roopta tangeek kuuyu motokimii satyeet ako keetik , kikwwam tuuka tukuun angutam biiko keetik kumenyeet mbareet. Kikweei ng'aleechu tang'eek mbu koreet tukul koobot munyeer. Yoo mere mite munyeet nyee yeeme bortoo kuyeeye biiko koobwa katwook , bortoo nyee weeti akoi meet. Miite subaak hataari miisin yoo mere mite munyeet bortoo:

Ambu leekok ako karimaamik: Mowoitu ng'ometeet nye karam

Mowoitu bortoo nye karaam

Ambuu Leekok cho katekesiiche: Miyatiitu meetit, yeeku lekweet nwwach ako meet

Ambu leekok chee mii moo: Inoomu moet

Isiiche leegok che manayam

Biiko che woech: Mowoitu ng'ometeet nye karam

Kaarartaetaap munyeet kutooku mbu koeet tugul , akoi olee motooku kabwaneetap kaatit.

Kiimuche kiiwongu karartaetap munyeet yo kaketeoshi iodine mbu chumbiit nyoo kyoome kwaak. Miite sheria mbu biiko cho yektooi chumbiit kookochii munyeet aritaap chumbiit nye yektooi.

Ambunee kyee sumanaani

Kyee sumanaani sigingeet yoo kaam cheesok chee nyigiseech munyeet yo imuuch kuriib munyeet manyoor borto nyee ibwonee kaatit. Mekeepiiman legook che beeti sukuuru sigingeet yoo ting'ee munyeet mbu borwook chekwaa.

Ole mekeyaktaa

Yoo keekochii lakwaang;ung boroointoo keyeeishe mbu sumanaani, mekweyey ngaleek chee rubee:

Legookaap skuul: Meekikochi leegok mkeebet kookochuu lukumek mbu sukuru

Cheesok che nyikiseech

1. Meekikochi chesook mkeebet kookochii lukumek mbu sukuru
2. Mekeetebe cheesok teebutook kubeete oli omdoii munyeet, oli keebunee beeko ak oli keechinee beeko sakityeek.

Faidaniik

Moomu kiito nyee inyorru kama lakweet yoo kayeeyisheening mbu sumanaani. Ndeene kle sumanaani mokeyeetchii emeet tugul yokaabok mbu kanyishook che bwooni. Yoo keeyey sumaanani meetyeechi serekali koonget yee yaame muunyet nyee tinge biiko , ndo maache keteshyii.

Miyotyeet

Moomi mioteyeet akee tukul nyee mite sumanaani. Lukumeek yoo kakinoomu kidogo matingee hida akee tugul. Yoo meemche tebutyeet isishneegei.

Kaaunyeet

Kiitakee tuguk nye rubekeei ako lakwaangug ku mekeuuny. Ng'alyoteet akee tugul nye meemwai mekeeuny. Unyooitin kanynook mere mokutook ambu yetaake tugul. Menyoru foomuni.

Lokoywook kuubo chiito nyeebo sumanaani

Yoo keecham iyeey sumaananii ingiing ngiit ndo kweey lakwanguung , keenamchiikey. Imuuche itayishoo saait akee tugul. Yooketayisho moomu hasara akaa tugul.

Itaakat iteep teebutyeet ake tuguul kuboo sumanani , kabla meenchemiishe ako ypmanatoou sumaneet.

Nambaanik kaap simuut ypp imeeche logoywook cheebo ariit

Yoo imeeche ingeet miisin, purchii chiito nyee iyongoninee sumanaani, **Stephen Onteri 0721765462 (P. O. Box 22458-00100, Nairobi), Jomo Kenyatta University ERC 067 587 0001.**

Ng'a;yonteetap siliintet/chiito nye riibe lekweet

Ating'ee manta kle ng'aleechu tugul chi kakemwowo kaalum nye tabon , kaachemishoo ngiit awuut aroot taap sumanaani. Kaanyoru baroointo ateep tebuteek angekechiibono kuut kaacham.

Kaanthetap sikiientet /chiito nyee riibe lekweet -----------------------------------

Kaanythetap lekweet--- Classit---------------------------

Beeshet------------------------

Kaanneetap chiito nyee soome borointoo -------------------------------------

Appendix V: JKUAT Institutional Ethics Review Committee

Iodine deficiency occurs when iodine intake falls below recommended levels

JOMO KENYATTA UNIVERSITY
OF
AGRICULTURE AND TECHNOLOGY
P. O. Box 62000-00200 Nairobi, Kenya Tel 0675870225 OR Extn 3209
Institutional Ethics Review Committee

November 2nd, 2018 **REF: JKU/2/4/896A**

Stephen Onteri,
Department of Food Science and Technology.

Dear Mr. Onteri,

RE: ASSESSMENT OF IODINE STATUS AND RISK FACTORS FOR DEFICIENCY AMONG PRIMARY SCHOOL CHILDREN IN MT. ELGON CONSTITUENCY, BUNGOMA COUNTY, KENYA

The JKUAT Institutional Ethics Review Committee has reviewed your responses to issues raised regarding your application to conduct the above mentioned study with you as the Principal Investigator.

The is to inform you that the IERC has approved your protocol. The approval period is from November 2nd 2018 to November 2nd 2019 and is subject to compliance with the following requirements:

a) Only approved documents (informed consent, study instruments, study protocol, etc.) will be used.
b) All changes (amendments, deviations, violations, etc.) must be submitted for review and approval by the JKUAT IERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the IERC immediately.
d) Any changes, anticipated or otherwise that may increase the risks to or affect the welfare of study participants and others or affect the integrity of the study must be reported immediately.
e) Should you require an extension of the approval period, kindly submit a request for extension 60 days prior to the expiry of the current approval period and attach supporting documentation.
f) Clearance for export of data or specimens must be obtained from the JKUAT IERC as well as the relevant government agencies for each consignment for export.
g) The IERC requires a copy of the final report for record to reduce chances for duplication of similar studies.

Should you require clarification, kindly contact the JKUAT IERC Secretariat.

Yours Sincerely,

J.K.U.A.T
DIRECTOR,
RESEARCH DEPARTMENT (RPE)
P O Box 62000-00200
NAIROBI

Dr. Patrick Mbindyo
DIRECTOR, RESEARCH

Setting Trends in Higher Education, Research and Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
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National Commission for Science, Technology and innovation
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TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 22066

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MR. STEPHEN N ONTERI
of JOMO KENYATTA UNIVERSITY, 22458-100 Nairobi,has been permitted to conduct research in *Bungoma County*

on the topic: *ASSESSMENT OF IODINE STATUS AND RISK FACTORS FOR DEFICIENCY AMONG PRIMARY SCHOOL CHILDREN IN MT. ELGON CONSTITUENCY, BUNGOMA COUNTY, KENYA*

for the period ending:
26th November,2019

Permit No : NACOSTI/P/18/78691/26763
Date Of Issue : 27th November,2018
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/18/78691/26763**

Date: **27th November, 2018**

Stephen N. Onteri
Jomo Kenyatta University of
Agriculture and Technology
P.O. Box 62000-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of iodine status and risk factors for deficiency among primary school children in Mt. Elgon Constituency, Bungoma County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Bungoma County** for the period ending **26th November, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Bungoma County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Bungoma County.

The County Director of Education
Bungoma County.

REPUBLIC OF KENYA

THE PRESIDENCY
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telephone: 055- 30326
FAX: 055-30326
E-mail: ccbungoma@yahoo.com
When replying please Quote

REF:ADM.15/13/VOL.11/22

Office of the County Commissioner
P.O. Box 550 - 50200
BUNGOMA

22nd[th] February, 2019

Deputy County Commissioner
MT. ELGON SUB COUNTY

RE: RESEARCH AUTHORIZATION -STEPHEN N. ONTERI

Reference is here made on a letter Ref; **NACOSTI/P/18/78691/26763**dated 27[th] November, 2018 from the National Commission for Science, Technology and Innovation on the above subject refers.

The bearer of this letter Mr. Stephen N Onteriis a student at Jomo Kenyatta University of Agriculture and Technology**(AG322-0077/2016)** undertaking an MSc in Food Science and Nutrition. Mr Stephenhas sought authority to carry out research on, " **Assessment of Iodine Status and Risk Factors for Deficiency Among Primary School Children in Mt. Elgon constituency *Bungoma County*, *Kenya*"** for a period ending 26[th] November 2019.

Authority is hereby granted for the specific period and any assistance accorded to him in this pursuit would be highly appreciated by this office.

L. Walukhu
For: County Commissioner
BUNGOMA COUNTY

COUNTY COMMISSIONER
BUNGOMA

REPUBLIC OF KENYA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
State Department of Education – Bungoma County

When Replying please quote
e-mail: bungomacde@gmail.com

Ref NO: BCE/DE/19/VOL.1/238

County Director Education
P.O. Box 1620-50200
BUNGOMA
Date: 22nd February, 2019

The Sub County Director of Education
Mt. Elgon

RE: AUTHORITY TO CARRY OUT RESEARCH – STEPHEN N. ONTERI
REG NO. NACOSTI/P/18/78691/26763

The bearer of this letter **Stephen N. Onteri** of Jomo Kenyatta University of Agriculture and Technology, has been authorized to carry out research on ***"Assessment of iodine status and risk factors for deficiency among primary school children in Mt. Elgon Sub County, Kenya"*** for the period ending 26th November, 2019

Kindly accord him the necessary assistance.

Caleb Omondi
FOR: COUNTY DIRECTOR OF EDUCATION
BUNGOMA

REPUBLIC OF KENYA

THE PRESIDENCY

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

Telegrams "DISTRICTER" Mt. Elgon
Email add:dcmtelgon@gmail.com
Fax: 0202376164
When replying please quote

DEPUTY COUNTY COMMISSIONER
MT. ELGON SUB COUNTY
P O BOX 1 - 50203
KAPSOKWONY

Ref: ED.12/18 VOL.1/218

26TH FEBRUARY, 2019.

THE ACC - KAPSOKWONY DIVISION
THE ACC - KAPTAMA DIVISION
ALL CHIEFS
MT. ELGON SUB COUNTY

RE: RESEARCH AUTHORIZATION
STEPHEN N. ONTERI -REG. NO NACOSTI/P/18/78691/26763

The bearer of this letter is a student at Jomo Kenyatta University of Agriculture and Technology undertaking a MSC in Food Science and Nutrition. He has been authorized to carry a research on **Iodine Status and Risk Factors for Deficiency among primary school children in Mt. Elgon Constituency Bungoma County** for a period three (3) months beginning from 4th March 2019.

The purpose of this letter is therefore to request you to provide him with the necessary support.

Duncan A. Murefu
For Deputy County Commissioner
Mt. Elgon Sub County

CC. STEPHEN N. ONTERI