ASSESSMENT OF IODINE STATUS OF THE SCHOOL GOING CHILDREN OF SURYODAYA MUNICIPALITY, ILAM

by

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Assessment of Iodine Status of the School Going Children of Suryodaya Municipality, Ilam

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Approval letter

This *dissertation* entitled *Assessment of Iodine Status of School Going Children of Suryodaya Municipality, Ilam* presented by Praja Adhikari has been accepted as the partial fulfillment of the requirements for the Bachelor degree in Nutrition and Dietetics.

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Abstract

Iodine deficiency disorder (IDD) is a major micronutrient deficiency problem in Nepal. This study was conducted with objective to measure the Urinary Iodine Excretion (UIE) and attempts were made to relate urinary iodine with salt use and other sociodemographic variables of household of primary school children of Suryodaya municipality of Ilam district of Nepal.

A community based cross section study was conducted in two schools of study area selected randomly (lottery method). A total of 202 school children of 6-12 years were recruited for the study to collect urine and salt samples for UIE and Salt Iodine Content (SIC) measurement respectively and detail information of study population was achieved from their household. UIE was measured by ammonium persulphate digestion microplate (APDM) method and SIC was estimated by rapid test kit (RTK). Data were expressed in frequency, mean±SD and median, Inter Quartile Rang (IQR) according to the nature of data. Chi-square test, Mann-Whitney U test and Kruskal-Wallis test were used to test the significance considering $p \leq 0.05$ at 95% confidence interval. It was found that Median Urinary IE of the study population is 152.14 µg/L. Overall it was found that 30.7% children had urine iodine level less than the normal WHO levels. The availability of adequately iodized salt was 93.1% as measured by RTK. There was statistically significant association between consumed salt iodine content and urine iodine excretion level ($P < 0.05$).

This survey result concluded that the median UIE of the study population indicates the adequate iodine intake and optimal iodine nutrition in study population. This study shows that IDD should be continuously monitored and awareness program should be implemented focusing on importance of iodized salt, its practice and storage in preserving iodine of salt and obtaining optimal iodine level.

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Abbreviations	Full form
GCEP	Goiter and Cretinism Eradication project
GCP	Goiter Control Project
ICCIDD	International Council for Control of Iodine Deficiency Disorders
IDD	Iodine deficiency disorder
MOCS	Ministry of Commerce and Supplies
MOPH	Ministry of Health and Population
NIDDCP	National IDD Control Program
NIDDSS	Nepal Iodine Deficiency Disorder Survey Status
NLSS	Nepal Living Standard Survey
NMSS	Nepal Micronutrient Survey Status
NSISIDD	National Survey and Impact Study for Iodine Deficiency Disorders
Ppm	Parts per million
SAC	School-age children
SIC	Salt Iodine Content
T3	Tri-iodothyronin
T4	Thyroxin
TCL	Two Child Logo
Tg	Thyroglobulin
TGP	Total Goiter Prevelance
TGR	Total Goiter Rate
TSH	Thyroid Stimulating Hormone
UI	Urinary Iodine

UIC	Urinary Iodine Concentration
UIE	Urinary Iodine Excretion
UNICEF	United Nations Children’s Fund
USI	Universal Salt Iodization
WHO	World Health Organization

Part I

Introduction

1.1 Background to the study

Iodine deficiency is a major public health problem throughout the world, particularly in developing countries. Iodine is a micronutrient which is essential for human growth and normal functioning of the body and is needed in very small quantity regularly. A deficiency of iodine leads to hypothyroidism, impaired mental and physical development in infants, children and adolescents, goiter, impaired mental function and reduced productivity in adults (UNCEF,2002) and an increased risk of spontaneous abortion, stillbirths, and congenital abnormalities in pregnancy (WHO, 2012).

Iodine is an essential component of the thyroid hormones: - tri-iodothyronine (T3) and thyroxin (T4) (Hetzel *et. al.*, 1999). Thyroid hormone plays a critical role during brain development (Anderson *et. al.*, 2003). The most devastating outcomes of iodine deficiency are increased perinatal mortality and mental retardation. Iodine deficiency is the most common cause of preventable brain damage in childhood which is the primary motivation behind the current worldwide drive to eliminate it (WHO,2004). The most common thyroid disorders in areas of adequate iodine intake are the autoimmune thyroid diseases, nodular goiter and iodine-induced hyperthyroidism (Arora*et. al.*,2010).

World Health Organization (WHO) estimated the worldwide prevalence of iodine deficiency using urinary iodine excretion (UIE) data collected for 92% of the world's population in the period from 1993 to 2003. Nearly two billion individuals have inadequate (UIE <100 µg/L) iodine nutrition, and occurrence of iodine deficiency was observed in 36.4% of school-going children (WHO, 2007).

Iodine deficiency is a major public health problem in Nepal, 19.4% of school going children are at risk. The prevalence of iodine deficiency in hilly and plain regions is 18.9 % and 9.5% respectively shown by previous studies (Gelal *et. al.*, 2010).

The natural source of iodine could be the food and vegetables grown from the iodine rich soil and sea foods and sea weeds. However, it could be easily leached from the soil especially when soil is exposed and lot of erosion takes place. Owing to the soil condition of Nepal, virtually there is no natural source of iodine. Therefore, there is need of providing supplemental iodine to control the IDD (NSISIDD, 2007).

Several indicators are used to assess the iodine status of a population: thyroid gland size, urinary iodine, iodine content of salt and the blood constituents, thyroid stimulating hormone (TSH), and thyroglobulin (Tg) (Buchinger*et. al*.,2007).

Iodine is rapidly absorbed in the circulation in the form of inorganic iodine, which is rapidly cleared by the kidneys. In humans; greater than 90% of iodine intake is excreted in the urine providing an estimate of current iodine intake rather than past iodine intake (Guttikoda *et. al.,* 2003). Urinary iodine excretion (UIE) is therefore considered a good biochemical marker of recent dietary intake of iodine and is the test of choice for evaluating the degree of iodine deficiency and its correction (ICCIDD *et. al.,* 2001).

Although Nepal has achieved the decreased prevalence of IDD and increased median UIE through Universal Salt Iodization USI and various public awareness programs, still it has not progressed to sustainable elimination of IDD as public health problem. This study is designed to access iodine nutrition status in Suryodaya municipality of Ilam by using different indicators i.e. urinary iodine excretion (UIE) and salt iodine content (SIC).

1.2 Problem statement and justification

Iodine deficiency disorders (IDD) are recognized as a global public health problem in developing mountainous countries like Nepal (WHO, 1998). Worldwide, nearly two billion individuals have inadequate iodine nutrition, and occurrence of iodine deficiency has been observed in 36.4% of school-going children. Iodine deficiency is a major public health problem in Nepal too, 19.4% of school going children are at risk. The prevalence of iodine deficiency in hilly and plain regions is 18.9 % and 9.5% respectively shown by previous studies (Gelal *et. al.,* 2010).

Nepal has made significant progress in its USI program, as evidenced by the fact that the household coverage of adequately iodized salt has increased from 55.2%in 1998 to 80% in 2011(NDHS, 2011). Despite such progress for the country as a whole, there are still some regional disparities, with coverage of iodized salt much lower in the Far-west, Mid-west and Eastern Rural Hills (NLSS,2011) than in other parts of the country, which suggests that focused efforts are required to assure that the entire country is protected from IDD.

The age group recommended by WHO for IDD survey was 6 - 12 years. This age group was recommended to be used in the surveys in all the countries because children in this age group have a high vulnerability, easy access, and also, affected children develop an enlarged thyroid, in response to iodine deficiency and can be readily examined in large numbers in school settings (ICCIDD*et. al*., 2007) and as a representation of iodine deficiency in the community (Biswas *et. al*.,2006).

Suryodaya municipality is located in Ilam district of Nepal which is eastern region of Nepal and ranges from 900m to 1812m from see level. It may increases the chances of low availability of iodine in soil and water. The consumptions of salt used in these regions are mainly packet, crushed, crystal and Tibetan salt. Import of non-iodized salt due to porous border, inadequate supply, improper storage, loss during food processing, lack of transportation facility, supply of open salt for livestock consumptions and inadequate monitoring by the concerned authorities are primary reason behind the iodine deficiency in these regions (Gelal *et. al*., 2010).

In view of the above context the present study is conducted to find the prevalence of Iodine Deficiency Disorders and urinary iodine excretion levels in 6- 12 years' school going children of Suryodaya municipality, Ilam. The outcome of the study will explore the iodine status of school going children of suryodaya municipality of Ilam district.

1.3 Objective of the study

1.3.1 General objective

To assess the iodine status of the school going children of Suryodaya municipality of Ilam district of Nepal.

1.3.2 Specific objective

1. To measure the Urinary Iodine excretion (UIE) of school going children.
2. To measure Salt iodine content (SIC) of household salt used by those school going children
3. To find out the correlation between the UIE with SIC in the above study population.

1.4 Research questions

1. What is the existing iodine status of school going children of 6 –12 years of Suryodaya municipality, Ilam?

1.5 Significance

The findings of this study will be remarkably supportive to

1. Provide information regarding the iodine status of school going children of 6 years – 12 years of age group to the governmental and non-governmental organization which will be helpful to initiate corrective measures for the problem.
2. Make people aware about the current real situation of iodine status in their surroundings.
3. Act as guide for the development of proper programme and its implementation in this community by undertaking the discovered facts.
4. Function as a tool to discover the problems related to storage practices of salt in household which is affecting their iodine uptake.
5. This study also provides information about effectiveness of ongoing salt iodization program conducted by STC.

1.6 Limitation of the study

1. This study is conducted with limited resources it makes impossible to include titration method which is well accepted quantitative method to measure iodine content in salt.
2. In rapid kit test subject variance may occur in visual observation of colour.
3. Finding cannot be generalized.
4. Actual information about family may not be reliable.
5. Clothing, weighing time (before or after meal), and time of height measurement (morning and evening) may cause some error.

Part II

Literature review

2.1 Iodine

Iodine (atomic mass, 126.9 amu) is an essential trace element in the endocrine system, vital for the production of thyroid hormones tri-iodothyronine (T3) and thyroxin (T4)in the thyroid gland. Thyroid hormones, and therefore iodine, are pertinent for mammalian life. In 1811, Courtois, French chemist, propounded iodine as a violet vapor arising from seaweed ash while manufacturing gunpowder for Napoleon's army. Gay-Lussac identified it as a new element, and named it iodine, from the Greek word, meaning "violet." Like the other halogens, iodine is highly reactive and therefore does not occur in its free state in nature. However, a solid form of iodine exists, where the molecule consists of two iodine atoms and appears as grey, black, violet, shiny crystals. Iodine was found in the thyroid gland by Baumann in1895. In 1917, Marine and Kimball showed that thyroid enlargement (goiter) was caused by iodine deficiency and could be prevented by iodine supplementation (Kimball, 1992).

Although, Iodine is needed in very small amount, it is essential for normal growth and development in animals and human. Iodine is an essential component of the thyroid hormones: tri-iodothyronine (T3) and thyroxin (T4) (Hetzel *et. al.*, 1999). Iodine is integral for the synthesis of thyroid hormone, and in the state of iodine deficiency thyroid hormones are synthesized inadequately resulting in decreased metabolism of key nutrients affecting overall development. Thyroid hormone plays a critical role during brain development (Zimmermann, 2006).

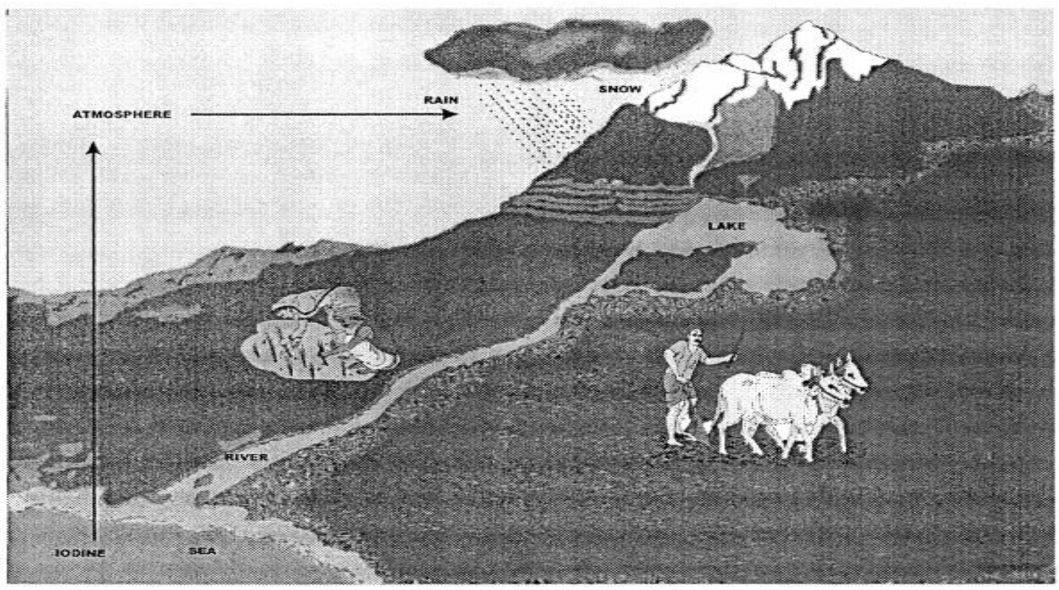
2.2 Dietary sources of iodine

Iodine exists in various forms; iodide (I^-); iodate (IO_3^-) and elemental iodine. The iodine content of food depends on the iodine content of the soil in which it is grown. The iodine present in the upper crust of the earth is leached by glaciation and repeated flooding, and is carried to the sea. Seawater is, therefore, a rich source of iodine (Koutras *et. al.*, 1980).

Naturally, sea fish, other seafood's, and seaweeds are rich sources of iodine suitable for human consumption. Iodine is also found in vegetables grown in soils containing this trace element and in milk products, egg, poultry and meat of animals whose diets contain sufficient iodine. Access to these food products containing iodine is limited in a large portion of the world (WHO and USI, 1996).

2.3 Iodine cycle in nature

Iodine (as iodide) is widely but unevenly distributed in the earth's environment. Iodine is present in topsoil which is absorbed and utilized by plants. Most iodide is found in the oceans (≈50 μg/L), and iodide ions in seawater are oxidized to elemental iodine, which volatilizes into the atmosphere and is returned to the soil by rain, completing the cycle. However, iodine cycling in many regions is slow and incomplete, and soils and ground water become deficient in iodine. Crops grown in these soils will be low in iodine, and humans and animals consuming food grown in these soils become iodine deficient (ICCIDD, 2007).



(Source: Zimmermann *et. al.*, 2009)

Fig. 2.1 Iodine cycle in nature

In plant foods grown in deficient soils, iodine concentration may be as low as 10 μg/kg dry weight, compared to ≈1 mg/kg in plants from iodine-sufficient soils. Iodine deficient soils are most common in inland regions, mountainous areas and areas of frequent flooding, heavy rainfall, which removes iodine from the soil **(**Assay *et. al.,* 2006).

Iodine deficiency in populations residing in these areas will persist until iodine enters the food chain through addition of iodine to foods (e.g. iodization). Nepal requires that salt be iodized at a minimum of 50 ppm of iodine (85 ppm of potassium iodate) at the factory, with the expectation that the salt will retain at least a level of 30 ppm at the retail level and 15 ppm at the household level**.** The topography of Nepal leaves it under a vulnerable situations**(**MOHP,2005)**.**

2.4 Goitrogenic factors

Goitrogens are substances that suppress the function of the thyroid gland by interfering with iodine uptake, which can, as a result, cause an enlargement of the thyroid. The risk of developing goiter during iodine deficiency is increased with the consumption of foods containing goitrogens. Potential goitrogenic substances or their precursors are widespread in vegetables of the Brassica family (broccoli, cabbage, mustard leaves etc). Naturally occurring goitrogens are present in various foods, such as millet, cassava, cabbage, turnips, radishes, maize, bamboo shoots, sweet potatoes and lima beans (Gaitan, 1990).

Cassava contains cyanogenic glycosides, which are a source of cyanide. In the body,it is converted to thiocyanate which is powerful goitrogenic substance as it is an anion with the same molecular size as iodine. Thiocyanate induces goiter by inhibiting uptake of iodine by the thyroid. Thiocyanate also inhibits the activity of thyroperoxidase (TPO) and inhibits the iodination of tyrosyl residues of Tg (Michot *et. al*.,1980).

2.5 Recommended daily intake (RDI) of iodine

The recommended daily iodine intake for the control of iodine deficiency varies and depends on the age (Papanastasiou and Vatalas, 2007). It varies from school going children, adults, infants, pregnant and lactating women with highest requirement in latter groups. Intake of iodine must be at least equal to the amount of hormonal iodine degraded at the level of the tissues and not recovered by thyroid gland (Stanbury and Hetzel, 1980).

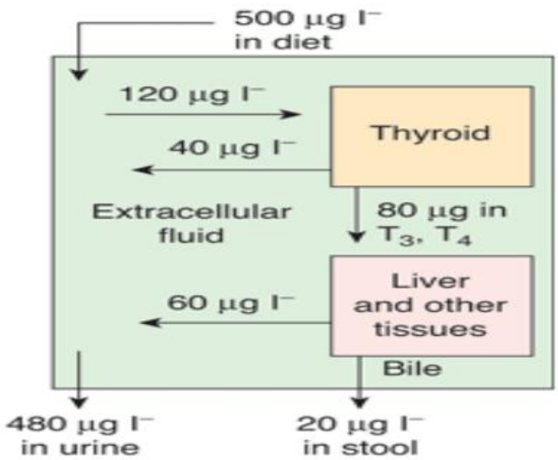
Table 2.1WHO/ICCIDD/UNICEF recommendation for daily iodine intake .

Age/Population group	Iodine Intake (µg per day)
Children 0-5 years	90
Children 6-12 years	120
Children ≥ 12 years + adults	150
Pregnancy	250
Lactation	250

Source: WHO/ICCIDD/UNICEF,2007

2.6 Absorption, transport and metabolism of iodine

Iodine is a fundamental raw material for thyroid hormone synthesis. Dietary iodide is absorbed by the large intestine and enters the circulation. Its subsequent fate is summarized in Fig 2.2. The minimum daily iodine intake that will maintain normal thyroid function is 150 µg in adults. In most developed countries, supplementation of table salt means that the average dietary intake is approximately 500 µg. The principal organs that take up circulating iodine are the thyroid, which uses it to make thyroid hormones, and the kidneys, which excrete it in the urine. About 120 µg/d enter the thyroid at normal rates of thyroid hormone synthesis and secretion. The thyroid secretes 80 µg/d in the form of T3 and T4, while 40 µg/d diffuses back into the extracellular fluid (ECF). Circulating T3 and T4 are metabolized in the liver and other tissues, with the release of a further 60 µg of Iodine per day into the ECF. Some thyroid hormone derivatives are excreted in the bile, and some of the iodine in them is reabsorbed (enterohepatic circulation), but there is a net loss of Iodine in the stool of approximately 20 µg/d. The total amount of Iodine entering the ECF is thus 500 + 40 + 60,or 600 µg/d; 20% of this Iodine enters the thyroid, whereas 80% is excreted in the urine (Zimmermann, 2006).



(Source: Zimmermann, 2006)

Fig. 2.2 Iodine Metabolism

2.7 Iodine deficiency disorder (IDD)

Iodine deficiency disorders (IDD) refers to all of the adverse effects and consequences of iodine deficiency in a population that can be prevented by ensuring an adequate intake of iodine (UNICEF, 2008). The impact of iodine deficiency depends to a large extent on the stage of development at which the deficiency exists. The foetus is particularly vulnerable and in utero iodine deficiency can cause irreversible cognitive and motor defects (Zimmermann, 2006).

The World Health Organization has estimated that elimination of iodine deficiency would prevent the brain damage that has cause irreversible mental handicap to at least 20 million people walking around today. Remarkable success has been achieved by the use of iodised salt to correct this deficiency in industrialised countries since 1920.However, there is still a very big lag in the use of this salt technology in developing countries for an at-risk population estimated by the WHO to reach one billion. In 1990, it had been estimated that among the 1572 million people in the world (28.9% of world population) exposed to iodine deficiency, 11.2 million people were affected by overt cretinism, the most extreme form of mental retardation due to the iodine deficiency and another 43 million people were affected by some degree of mental impairment. Iodine deficiency induces the brain damage and irreversible mental retardation is the most important disorders. It is a leading cause of preventable mental retardation worldwide (WHO, 1994).

Iodine deficiency has many adverse effects on growth and development. These are due to inadequate production of thyroid hormone and termed iodine deficiency disorder (IDD) (Zimmermann, 2008). If there is insufficient iodine present, the thyroid gland responds to iodine deficiency by swelling and adding new cells to capture more iodine. Goitre is thus the compensating enlargement of the thyroid gland caused by the effect of TSH, secreted in increasing concentration by the pituitary gland, following a decrease in thyroxin output secondary to iodine deficiency. In severe iodine deficiency, TSH levels are raised and free thyroxin levels are low. Iodine deficiency occurs in all age group but foetus, neonate, pregnant and lactating women are more vulnerable groups. The spectrums of iodine deficiency disorders are different in different age group. The table 2.7 shows the spectrum of IDD in different age group.

Table 2.2 The spectrum of iodine deficiency disorders (IDD)

Life stage	Disorder
Fetus	Miscarriage, stillbirths, congenital anomalies, increased perinatal and mortality, mental deficiency, deaf mutism, spastic diplagia,squint
Neonate	Myxoedematous cretinism: mental deficiency,dwarfism, hypothyroidism, psychomotordefects, neonatal hypothyroidism
Child and adolescent	Goiter, (subclinical) hypothyroidism, impaired mental function, retarded physical development
Pregnant and lactating women	Miscarriage, stillbirth; birth defects and congenital hypothyroidism in the offspring, lactating mother unable to provide sufficient iodine to newborn vulnerable to iodine deficiency
Adult	Goiter with its complications: hypothyroidism: impaired mental function, iodine-induced hyperthyroidism

(Source: WHO/UNICEF/ICCIDD, 2007)

2.8 Indicators of iodine deficiency - urinary iodine excretion

Several indicators are used to assess the iodine status of a population: thyroid size by palpation and/or by ultrasonography, urinary iodine (UI) and the blood constituents, TSH or thyrotropin, and thyroglobulin. Until the 1990s, total goiter prevalence (TGP) was recommended as the main indicator to assess IDD prevalence. However, TGP is of limited utility in assessing the impact of salt iodization. As UI is a more sensitive indicator to recent changes in iodine intake, it is now recommended over TGP. (Andersen *et. al*., 2008). Because >90% of ingested iodine is excreted in the urine, UI is an excellent indicator of recent iodine intake. UI can be expressed as a concentration (µg/L). UI can be measured in spot urine specimens from a representative sample of the target group, and expressed as the median, in µg/L (WHO *et. al*., 2007). In contrast, TSH is a sensitive indicator of iodine status in the newborn period (Knudsen *et. al.*,2000). However, difficulties in interpretation remain and the cost of implementing a TSH screening program is high. The value of thyroglobulin as an indicator of global IDD status has yet to be fully explored (Andersen *et. al*., 2008).

2.9 Salt iodine

It is most economical to correct iodine deficiency by the addition of iodine to the diet.This can be done through the addition of iodine to salt, water, various sources or in an oily form. Iodised salt will be the major resource for the elimination of IDD by the year 2000. Iodine in the form of potassium iodate can be readily mixed with salt at concentrations of 40 to 100 mg iodine per kg. The concentration used depends on the level of salt intake, the climate and the distance it has to be transported to provide the essential requirements of 150-200 micrograms of iodine per day ,the equivalent of less than a teaspoonful for a whole lifetime (WHO *et. al*., 2007).

It has been shown that the effects of iodine deficiency can be totally prevented by an effective iodised salt programme in Switzerland and some other countries where formerly there was severe mental deficiency (cretinism and deafmutism). In other Western countries, diversification of diet has also been a factor in the correction of iodine deficiency and the elimination of IDD. In Latin America there has been considerable progress. In Asia, some progress is being made with large populations in China, India and Indonesia; and in Africa, in Algeria, Kenya andEthiopia, but there is still a long way to go with 39 countries affected(Benoist *et. al*., 2008).

Salt iodization is currently the most widely used strategy to control and eliminate IDD. However, to be fully propitious in correcting iodine deficiency, salt must not only reach the entire affected population (in particular those groups that are the most susceptible, pregnant women) but it also needs to be adequately iodized (WHO*et. al*., 2007).

The WHO has recently estimated the worldwide prevalence of iodine deficiency,which was 36.4% in schoolchildren populations with the lowest prevalence in the Americas (10.1%), where the proportion of households consuming iodized salt is the highest in the world (90%). Surprisingly, the highest prevalence of iodine deficiency is in Europe (59.9%), where the proportion of households consuming iodized salt is the lowest (27%) and, furthermore, most countries have weak or nonexistent national programs. Thus, universal salt iodization (USI) is the recommended strategy for IDD control and after implementation, careful monitoring of progress towards sustainable elimination of IDD is essential (Benoist *et. al*., 2008)

The advantage of supplementing with iodized salt is that it is used by all sections of a community irrespective of social and economic status. It is consumed in the same level throughout the year. Its production is often confined to a few centers which mean that processing can occur on a larger scale and with better controlled conditions (Baral and Lamsal, 2002).

Government of Nepal, Ministry of Health and Population adopted a policy in 1973 to fortify all edible common salt with iodine under the 'Universal Salt Iodization (USI) Program'. Later in 1998, Ministry of Health and Population issued a 'two-child logo' for quality certification of iodized packet salt with 50 ppm iodine at production level (MoHP *et. al*., 2005).

The proportion of households consuming adequately iodized salt (atleast 15 ppm at the household level) is increased from 55.2% in 1998, 57.7% in 2005 and 77.0% in 2007, showing the positive impact of USI in Nepal (Gelal and Baral, 2010).

But still the target of >90% is to be met for sustained elimination of IDD. Standardized periodic testing of the iodine content in salt is a critical part of a salt iodization programme. Such monitoring is done to ensure adequate iodine levels at all points of the salt distribution system from production to consumption. So it is regarded as process indicator. There are two principal methods for measuring iodine levels in salt, rapid test kits and titration. Rapid test kit method provides a semiquantitative estimate of the iodine concentration at one of four levels, 0 ppm, 7 ppm, 15 ppm or 30 ppm based on the intensity of the color change. In contrast, titration provides more reliable and precise estimates of the iodine content of salt. For the intervention to be successful and sustainable, it is vital to monitor the iodine content of salt regularly. Iodometric titration, the traditional method for measuring iodine content, has problems related to accessibility and cost. Spot-testing kits are inexpensive, require minimal training, and provide immediate results (Pandav and Arora, 2000).

Nepal micro-nutrient status survey (1998) indicated that about 17.0% of salt samples were found to contain no iodine at all, while approximately 27.7% of the salt samples contained less than 15ppm (MOHP *et. al*., 2005).

In a study done by Joshi *et. al* (2004) in 3 district of Nepal, they found that 289 (16.0%) salt samples had < 15ppm iodine, 637 (35.3%) had 15-30 ppm and 649 (35.3%) have 30-50 ppm among 1803 total salt sample (Joshi, 2007).

2.10 Iodine deficiency status world wide

Iodine deficiency disorder (IDD) is a global public health problem with clusters around the mountainous regions of Europe, the central Mediterranean, South and Central America,Africa and Asia.It is one of the oldest and most insidious of human health problem. Iodine deficiency not only cause goiters, but may also result in irreversible brain damage in the fetus and infant and retard psychomoter development in the child. Iodine deficiency is the most common cause of preventable mental retardation;it also affects a child's learning ability. Though the prevelance varies, the problem of IDD is confined to developing countries.About 1000 million people are at risk for IDD, of which 200 million suffer from goiter, 5 million have gross cretinism with mental retardation and 15 million suffer from lesser mental defects (sarkar *et. al.*, 2007).

In 1980, the first global estimate from the World health organization (WHO) on the prevalence of goiter was reported. It estimated that 20–60% of the world's population was iodine deficient and/or goitrous, with most of the burden in developing countries and occurrence of iodine deficiency has been observed in 36.4% of school-going children and Southasia and sub-Saharan Africa are particularly affected (WHO *et. al*., 1998).

Table 2.3 Epidemiological criteria for assessment of iodine status based on median urinary iodine concentrations of School-age Children (≥6 years)

Iodine Intake		**Median UIE (µg/L)**
	Severe deficiency	<20 µg/L
Insufficient Iodine Intake	Moderate deficiency	20–49 µg/L
	Mild deficiency	50–99 µg/L
Sufficient		100–299 µg/L
Excessive		≥ 300 µg/L

(Source : WHO, 2007)

2.11 Iodine deficiency status of Nepal

Iodine deficiency disorder disorder is one of the most endemic problems in Nepal. First Iodine deficiency disorders (IDD) survey of Nepal reveals total goitre rate (TGR) of 55% of population in 1965 in three ecological regions, which increased to 57.6 % in 1979 and declined to 44.2% and 40% in 1985 and 1998, reached only 0.4% in 2007 survey. Iodine deficiency is a major public health problem in Nepal, 19.4% of its 21 million people are at risk. The prevalence of iodine deficiency in hilly and plain regions is 18.9 % and 9.5% respectively shown by previous studies (MoHP, 2007).

The Government of Nepal had taken the initiative since 1973, when USI became a long term strategy for the control of IDD in Nepal. Three National level IDD surveys have been conducted in Nepal on 1998, 2005 and 2007 respectively. These surveys have shown 43.6%, 27.4% & 19.4% iodine deficient school age children respectively (MoHP*et. al*.,2007).

Following are the Iodine Deficiency Disorder Elimination Programs in Nepal

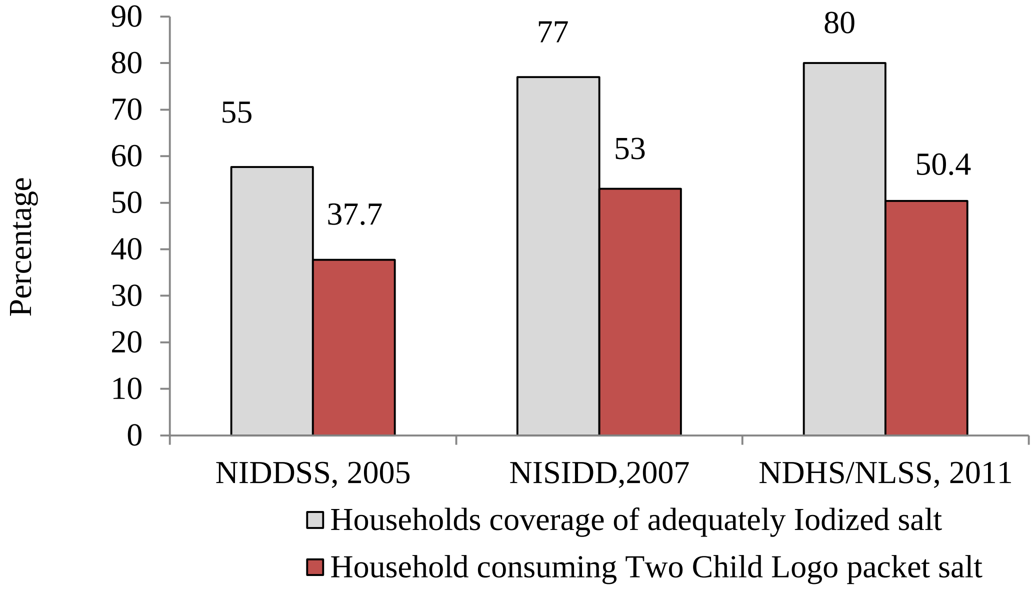
1. Universal Salt Iodization Program
2. Iodized Salt Social Marketing Campaign to promote iodized salt with Government Certified ‘Two Child Logo’(figure 2.3)with adequate iodine content (>= 15 ppm)

(Source: NIDDS, 2005)

Fig. 2.3 Two Child Logo used in Nepal

2.11.1 Iodized salt coverage at the household level

There has been a positive trend both in the proportion of households using adequately iodized salt (from 55.2% to 80% between 1998 and 2011), as well as in the proportion of households using two child logo (2CL) salt (from 10.3% in 1998 to 37.7% in 2005 and 59.4% in 2011).In spite of this overall progress at the national level, there is a disparity by rural-urban location, as the coverage of households consuming adequately iodized salt is considerably higher in urban areas (94%) than in rural areas (78%).



(Source : NPAIN, 2012)

Fig. 2.4 Household Coverage of adequately iodized salt and 2CL salt in percentage (1998 to 2011)

2.11.2 Trends in the Median UIE of Nepal

A major indicator corresponding to iodine nutrition and reflecting recent changes in iodine intake is the concentration of iodine in urine or Urinary Iodine Excretion (UIE) (WHO, 2007).

UIE is also termed as UIC (Urinary iodine concentration). For all the three national surveys, UIE was the primary indicator used to assess the iodine status and the prevalence of IDD. The median UIE of Nepal has been consistently increasing from 143µg/l in 1998 (NMSS,1998) to 188µg/l in 2005 (NIDDS Survey, 2005)and most recently to 202.8 µg/l in 2007(IDD survey,2007).

National Survey in 1998 (NMSS, 1998), 13.6% of all School Going Children had UIE values below 50µg/l, a figure which has since declined to 9.5%in 2005 (NIDDS Survey, 2005). The 1998 survey revealed that 35.1% SAC had UIE values below 100 µg/l, while the percentage below this cut-off has since declined to 27.4% in 2005 (NIDDS Survey, 2005) and 19.4% in 2007 (IDD Survey, 2007). These values indicate considerable improvement in the iodine status and progress towards the elimination of IDD in the country.

Three National level IDD surveys have been conducted in Nepal on 1998, 2005 and 2007 respectively. These surveys have shown 43.6%, 27.4% & 19.4% iodine deficient school age children respectively (MoHP*et. al*., 2007).

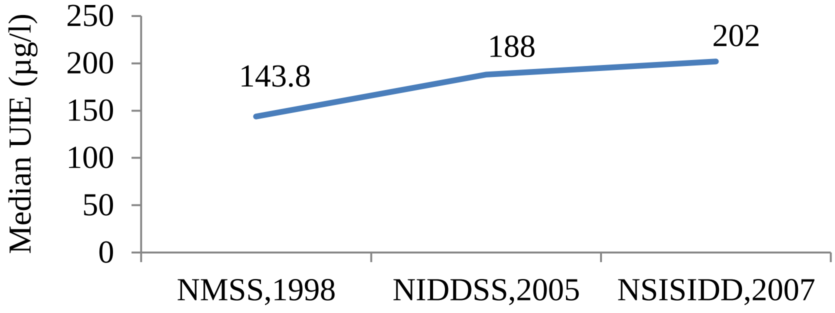


Fig. 2.5 Trends in the Median UIE (µg/l) between 1998 and 2007

Some of the similar studies performed in Nepal and studied UIE of the school going children are found. Gelal *et. al.* conducted a population based cross sectional study in schools of Dhankuta and Dharan. A total of 385 samples of both urine and salt were collected from school children aged 6 -12 yrs. Urinary iodine excretion (UIE) was measured in casual urine samples by the ammonium- persulphate digestion microplate (APDM) method and salt iodine content by using a semi quantitative rapid test kit. The median UIEs of school children of Dhankuta and Dharan were 157.1 µg/L and 180.3 µg/L respectively. The percentage of iodine deficient (UIE <100 µg/L) children was 26.6% in Dhankuta and 15.6% in Dharan. The majority of children consumed packet salt. The percentages of salt samples with adequately iodized salt (≥ 15 ppm) were 81.3% in Dhankuta and 89.6% in Dharan. Eastern Nepal is continuously progressing towards the sustainable elimination of iodine deficiency disease as illustrated by a normal median UIE and the majority of households consuming adequately iodized packet salt. It is found that there was presence of severe iodine deficiency in areas with adequate salt iodization (Gelal *et. al.*, 2008).

Joshi *et. al.* performed a study with objective to assess the urinary iodine among the school children of Kavre, Lalitpur and Parsa districts. Attempts were made to relate urinary iodine with salt use and other sociodemographic variables. Altogether 190 urine samples

(74 samples from Kavre, 89 from Parsa and 27 from Lalitpur district) were collected from school children aged 5-13 years. The urinary iodine was analyzed by using urinary iodine assay kit (Bioclone Australia Pvt Limited). It was found that 3.2% children had urine iodine concentration below 20µg/l. Similarly, the percentage of children with urine iodine concentration 21- 50 µg/l, 51-99 µg/l, 100-299 µg/l and above 300 µg/l were 14.2%, 10.5%, 43.7% and 28.4% respectively. Iodine deficient population of school children was 39.2% of Kavre, 19.1 % of Parsa and 25.9% of Lalitpur. Overall, it was found that 27.9% children had urine iodine level less than the normal WHO levels. The median urine iodine level was 139.0 µg/l of Kavre, 266.7 µg/l of Parsa and 244.4µg/l of Lalitpur school children. Urinary iodine excretion (UIE) median value among male students was 211 .9 µg/l, among female students was 190.2 µg/l and the difference was statistically insignificant (P > 0.05). There was no significant correlation between consumed salt iodine level and urine iodine excretion level (P > 0.05).. This study shows that IDD continues to be prevalent in the country as a major public health problem, which requires strengthening effective intervention program and other preventive measures (Joshi *et. al*., 2006).

Gelal *et. al.* conducted a population based cross sectional study among 1,094 school age children which was undertaken to evaluate the iodine status of Nepalese school age children by measuring urinary iodine excretion (UIE). Spot urine samples were collected from all children and UIE was measured during February to March 2007 by an ammonium persulfate digestion microplate (APDM) method. The median UIE at the national level was 193.1 0 µg/l, indicating adequate iodine intake in Nepalese school children. The proportion of the population having UIE below 50µg/l and below 100 µg/l was 4.5% and 22.0%, respectively. Determination of precision of the method was done following calculation of the inter and intra assay coefficient of variation (CV). At low, medium and high concentrations of urinary iodine the intra assay CVs were 6.3, 1.8 and 1.9%, respectively. The inter assay CVs for low, medium and high concentrations of urinary iodine were 11.9, 4.9 and 6.2%, respectively. Therefore, they found current iodine nutrition status is at satisfactory levels in Nepal (Gelal *et. al*., 2009).

Chaudhari *et. al.* under took a study to find out the iodine nutrition and thyroid function status and among school age children of Sunsari and Dhankuta districts. Children of 6-12 years' age were recruited from the selected four schools of those two districts of Eastern Nepal. A total of 386 urine and 142 venous blood samples were randomly collected from the 772 children after written consent of the school authority and/or parents. UIE was estimated by ammonium persulphate digestion microplate (APDM) method using Sandell Kolthoff's reaction to find out the iodine status of the children. Blood samples were analyzed for thyroid function test based on the enzyme linked immune sorbent assay (ELISA) by using commercial kits from Human, Germany. Median UIE of Dhankuta and Sunsari were 238.00 ug/L and 294.96 ug/L respectively. Relatively higher percentage (31 .8%) of subclinical hypothyroid cases was found in Sunsari than Dhankuta (29.59%) (Chaudhari *et. al.*, 2012).

2.12 The risks of excess iodine intake

Iodine deficiency impairs thyroid function similarly, iodine excess, including overcorrection of a previous state of iodine deficiency, can also impair thyroid function. The effect of iodine on the thyroid gland is complex with a "U shaped" relation between iodine intake and risk of thyroid diseases. Both low and high iodine intake are associated with an increased risk of thyroid disorders. Healthy adults can tolerate up to 600-1100 µg iodine/day without any side effects (WHO, 2007).

However, this upper limit is much lower in a population which has been exposed to iodine deficiency for a prolonged period in the past. The optimal level of iodine intake to prevent any thyroid disease may be a relatively narrow range around the recommended daily intake of 150 µg (McGuire and Galloway, 1994). Tolerable upper intake level for iodine is given below in table 2.4.

Table 2.4 Tolerable upper intake level for iodine (µg/day)

Age group	EC/SCF, 2002	IOM, 2001
1-3 years	200	200
4-6 years	250	300
7-10 years	300	300
11-14 years	450	300
15-17 years	500	900
Adult	600	1100
Pregnant women >19 years	600	1100

Part III

Materials and methods

3.1 Research design

This study has taken school going children of Suryodaya municipality, Ilam as its study population and cross sectional design was used to collect primary data from the selected sample by following two ways.

1. Urine and salt samples of school going children were taken from their schools
2. Household survey with the help of semi-structured questionnaires.

3.2 Study area

Study area was **S**uryodaya municipality of Ilam district which is formed by merging 3 VDCs (Phikkal, Panchakanya and Kanyam) in 2014, has an elevation of 5135 ft with the total population of 17,240.

Fig. 3.1 Map of study area (Suryodaya Municipality)

3.3 Study variable

Study variable were categorized into two groups:

1. **Dependent variable:** urinary Iodine Excretion and salt iodine content
2. **Independent variables:** Three categories of factors were assessed as independent variables**;**
   a) Socio-economic and demographic variables; Head of Households, ethnicity, religion, family size, income, education and occupation.
   b) Child characteristics; Age, Sex, height and weight
   c) Kitchen practices; Type of salt, type of salt container, time of adding salt while cooking, place of store

3.4 Sampling technique

A simple random sampling procedure (lottery method) was used in the study. The names of all the schools in Suryodaya municipality were collected from the all 3 VDC profile. Two schools were randomly selected from the list of schools in the community. As a sampling technique of our study was purposive, all school children of age group 6 to 12 years were selected as a study population. The total sample size was 202 children.

3.5 Target population

Primary school children of the age group 6-12.

Inclusion criteria

Primary school going children of age group of 6-12 years

Exclusion criteria

Schools having the current history of micronutrient supplements.

Children having severe illness

Children who did not want to participate in the study

3.6 Sample size

The calculation of the sample size will be done by using the statistical formula,

$n = t^2. P. (1\text{-}P) / m^2$

Where, n = required sample size

t= confidence interval at 95% (standard value of 1.96)

p=estimated prevalence of IDD 18.9 %

m = margin of error at 5% (standard value of 0.05)

Here, p was estimated on the basis of research conducted in 2007, a nationwide survey showed that 9.5% and 17.9% of school going children had urinary iodine excretion (UIE) less than 100μg/L in the Eastern plains and hills, respectively. Gelal *et. al.* is the latest research study done in 2010 on prevalence of IDD among school going children. The result showed that in eastern hills 18.9% of schools going children were Iodine deficient (Gelal *et. al*., 2010). Thus, this 18.9% is taken as the estimated prevalence of IDD (p) for the calculation of sample size for my research study.

The sample size will be obtained as below,

$n = t^2. P. (1\text{- }P) / m^2$

$= \{1.96^2 * 0.189 * (0.811)\}/0.05^2$

$= \{3.8416 * 0.189 * 0.811\}/0.0025$

$= 235.53 \sim 235$

Therefore, the sample size of this study was 235.due to limited time and money only 202 sample were taken.

3.7 Research instrument

Equipments needed for performing the survey were;

a) Child weighing machines (Seca scale): Child weighing machines having capacity of 100kg (1 piece).

b) Height measuring stand (Stadiometer): The height measuring tape of 5ft capacity (1 piece).

c) Questionnaire: A well designed set of questionnaire to collect information on household characteristics, food availability and its consumption.

d) Urine vile, plastic pouch for salt collection, rapid iodine test kit and ice box.

e) Instrument used during analysis: Multi pipet, sealing cassette and Microtiter reader etc.

3.8 Pre –testing

The study was pre- tested among School going children from age group 6-12 years selected area under sampling procedure. The pre-testing was conducted to establish accuracy of questionnaire and to check for consistency in the interpretation of questions and to identify ambiguous items. After review of instruments all suggested changes were made before being administered in the actual study.

3.9 Validity and reliability

To ascertain the degree to which the data collection instruments would measure what they were purposed to measure, the instruments were validated by a group of professionals from Central Campus of Technology, Department of Nutrition and Dietetics. The aspects tested in the questionnaire were also drawn from the available literature in NIDDS 2005. The questionnaire was also pre-tested prior to data collection to ascertain content and face validity.

Reliability refers to quality control measure of data collected. Questionnaire was checked daily for completeness, consistency and clarity as mentioned earlier.

3.10 Data collection techniques

Prior to the sample collection, the purpose of the visit was explained to the Headmaster/Principal of the School. Students and parents were informed through the Headmaster/Principal regarding the purpose of the study.

3.10.1 Anthropometric measurements include Height and Weight

Height: The height of the children was taken using a portable standiometer calibrated in centimeters (cm). The children were measured without shoes on a flat floor. A good standing posture was maintained before measurement. The heels were pulled together touching the base of the wall. The head was erect and hands hung at their sides in natural manner. The child's line of sight was in level with the ground for accuracy. The measurements were taken to the nearest 0.1 cm. after the head piece was placed on the head of each subject; the reading was taken to the nearest 0.1cm.

Weight: The weight of the children was taken using a Salter beam balance scale this was calibrated in kilograms and pounds. The scale was adjusted to zero before each measurement. The children were weighed with minimum clothing. The reading was taken to the nearest 0.1 kg. Ages of the children were recorded from the school records on admission.

3.10.2 Salt sample

Detailed instructions were given to children and were instructed to bring two tea spoonful (approximately 15 gram) salt samples from their houses which they used for every day purpose. Each child was provided a clean, moisture free, tightly closing plastic pouch to bring the sample prior one day of salt sample collection.

3.10.3 Urine sample

Spot urine samples were collected from all the eligible children in a clean, numbered, tightly screw capped 15 milliliters plastic vial. The samples were transported in an ice pack to the biochemistry laboratory of BPKIHS and were analyzed by using ammonium persulfate digestion microplate (APDM) method (ICCIDD *et. al*.,1993).

3.10.4 Semi structured questionnaire

The questionnaires comprised mainly of details on household profiles like age, sex, education level and occupation of household members and household size, type of salt, consumption of goitrogenic food etc. Interview was conducted with parents/care takers of the children to fill the questionnaire.

3.11 Data analysis

Data were entered in Microsoft Excel and IBM SPSS Statistics v20.0 for Windows was used to find the relevant calculation from the findings

1. Descriptive statistics: Frequency, Mean & Standard Deviation (SD), and Median & Inter Quartile Range (IQR) were used to represent the data whenever they needed.

2. Inferential statistics: Chi Square Test, Mann-Whitney U test and Kruskal-Wallis test were applied whenever they needed.

3.11.1 Chemical analysis of urine sample using APDM method

Material for Laboratory Analysis: **Reagents**

Ammonium persulfate solution (35% w/v): 35g of ammonium persulfate $(NH_4)2S_2O_8$ was dissolved in distilled water and finally made up to 100 ml with distilled water.

Arsenious acid solution (1% w/v, 0.05 mol/l): 5g of arsenic trioxide (As_2O_3) was dissolved in 100 ml NaOH 93.5% w/v. In an ice bath, 16 ml of concentrated H_2SO_4 was added slowly to form solution. After cooling, 12.5g of NaCl were added and the mixture was diluted with cooled distilled water to 500 ml. The final solution was filtered with Whatman No 1 filter paper.

Ceric ammonium sulphate solution (1.2% w/v, 0.02 mol/l): 6g of ceric ammonium sulphate dehydrate were dissolved in 3.5N H_2SO_4 and adjusted to a final volume of 500 ml with the same acid solution.

Standard iodine standard solution (100µg I/ml): In a 100 ml volumetric flask, 168.8 mg of KIO_3 was dissolved in distilled water as a stock solution. After making 100 and 10,000-fold dilutions, working solutions of 25, 50, 75, 100, 200, 300,400, 500 and 600 µg I/ml were prepared by diluting with distilled water.

Principle:

Urine samples are digested with ammonium persulfate to remove interfering substances.

After digestion, urinary iodine was measured by Sandell-Kolthoff's reaction. In this reaction iodine catalyzed reduction of colour of Cerric (Ce^{4+}) to Cerrous (Ce^{3+}) ion by Arsenate (As^{3+}) ion in acidic conditions. Iodine acts as catalyst of Sandell-Kolthoff's reaction. (Ohasi*et. al.*, 2000)

Sandell-Kolthoff's reaction:

$$As^{3+} + I_2 \longrightarrow As^{5+} + 2I^-$$

$$2Ce^{4+} + 2I^- \longrightarrow 2Ce^{3+} + I_2$$

(Yellow colored) (Colorless)

Procedure:

Calibrators and urine samples 50µL each transfer into the well of microtitre plate. Then, 100µL ammonium persulphate (fresh) solution was added in each well. After that Plate was set in sealing cassette and cassette was tightly closed. Sealing cassette was placed in oven at temperature 110ºC for 60 min for digestion. After digestion, sealing cassette was cooled to room temperature to avoid the condensation of water vapor on the top of the wells and stopped the digestion. Cassette was opened and 50µL of digested aliquot was transferred into other corresponding wells of next plate. 100µL arsenious acid solution was added to each well and mixed properly. And then 50µL cerric ammonium sulphate solution was added in each well (within 1 min after addition of Arsenious acid solution) using multichannel pipette. The mixture was left for 30 min at 25ºC. Finally, absorbance was measured at 405nm with a microtitre plate reader.

Fig. 3.2 Sealing Cassette used in estimation of urinary iodine.

Graph was plotted with the help of MS-Excel by placing Log mean absorbance at Y-axis and concentration of iodine calibrators at X-axis. The equation y = mx + c of this straight line was taken, in which y represented absorbance of the iodine calibrators and test sample, m represented the slope of the line, x represented the concentration of calibrators and test sample and c represented the constant.

3.11.2 Qualitative analysis of salt iodine content

Measurement of salt iodine content (by MBI rapid test kit):

i. Two drops of test solution were added on the surface of the salt from the white ampoules by gently squeezing.
ii. Color on the salt was compared with color chart.
iii. Iodine content in salt was determined by comparing color between salt and color chart.

Interpretation:

On the basis of color chart, iodine content in salt is divided into three groups

- No color — Zero (0) ppm iodine (No iodine)
- Light blue color — <15 ppm iodine (Not adequate)
- Dark blue color — >15 ppm iodine (Adequate iodine)

Fig. 3.3 Colour chart used to detect salt iodine concentration by rapid test kits.

3.13 Logistical and Ethical Consideration

Ethical clearance was obtained from Nepal Health Research Council. Also, the consent to conduct the research was obtained from the schools and parents of respective children who were selected for conducting the research.

Respondents were assured that the data collected would be for the purpose of the study and would be treated with the uttermost confidentiality.

Part IV

Result and discussion

A community based cross sectional study was conducted among school going children of Suryodaya municipality of Ilam district of Eastern Nepal. In this study, study population was taken from schools which were selected randomly using lottery method; anthropometric measurement of study population and their urine sample were taken and salt used in their household were asked to bring in their schools on next day. Other information related to our study was taken from household of those school going children by interviewing their parents using semi structured questionnaire. A total of 202 school going children were included in the study with a response rate of 100%.

4.1 Descriptive statistics of schools

Ilam Saijyoti English Boarding School formally of Fikkal VDC and Shree Krishna UchhaMadyamik bidhyalaya. formally of Kanyam VDC were selected school for sample collection. Out of total 202 participants, 127(62.9%) children were enrolled from Saijyoti school and 75 (37.1%) from Krishna Ma Vi. A total of 121 (59.9%) were boys and 81 (40.1%) were girls.

Table 4.1 Descriptive statistic of sample population

Statistics	Frequency	Percentage
Saijyoti E.B.School	127	62.9
Shree Krishna UchhaMa Vi	75	37.1
Boys	121	59.9
Girls	81	40.1

4.2 Descriptive characteristics of school going children

In this study, age group of school going children was 6-12 years were chosen from class U kg to class 6 who were eligible to include in our study. The mean age group of study population was found to be 9.51 with standard deviation (SD) 1.60 years where as mean height was 130.20with SD 14.07 cm and mean weight was 26.74 with SD 6.90 kg. Table no 4.2 depicts the mean±SD of age, height and weight of school going children of age group 6-12 years.

Table 4.2 Descriptive characteristics school going children

Statistics	**Age (Years)**	**Height (Cm)**	**Weight (Kg)**
N	202	202	202
Mean	9.51	130.20	26.74
Std. Deviation	1.60	14.07	6.90

4.3 Socio-demographic characteristic of house hold of school going children

A survey was conducted in household of those school going children in order to find other information like Socio-economic and demographic variables; Head of households, religion, family size, income, education, occupation etc. and Kitchen practices like type of salt, type of salt container, time of adding salt while cooking, place of store etc. which may affect their iodine status. The frequency and percentage of all the demographic characteristics and other parameter of study population is expressed in table 4.3.

Majority of the school children were non-vegetarian 176 (87.1%) and only 26 (12.9%) were vegetarian. Out of 202, 93.1% house heads were literate and only 6.9% were illiterate. All the families i.e.; 100% had heard of the iodized salt (aayo nun) with two child logo whereas NIDDS survey, 2005 had showed that 82.3% in Eastern and Central Hills had heard and IDD survey 2007 had showed that 83% of the study population in nation level had heard about iodized salt (NIDDS Survey 2005and IDD Survey,2007) . In contrary, in our study only 63.4% households knew the importance of iodized salt as compared to 75% respondents of IDD survey 2007 who knew the importance of iodized salt (IDD Survey, 2007). The religion distribution showed mixed composition with higher percentage of Hindu (59.9%), followed by Buddhist (24.8%), Kirat (11.4%) and Christian (8%). Survey shows 51.5% of the family head engaged in Agriculture, followed by Business (29.75%), Service (11.9%) and other (6.9%) respectively. Mean family size was 5.79±0.76 and mean food secured months in a year was 11.25±1.32 months.

Table 4.3 Socio-demographic characteristic of household of school going children

Statistics	**Subgroup**	**Frequency**	**Percentage**
Dietary habit	Veg	26	12.9
	Non-Veg	176	87.1
Education status	Literate	188	93.1
	Illiterate	14	6.9
Heard about iodized salt	Yes	202	100.0
Importance of iodized salt	Yes	128	63.4
	No	74	36.6
Religion	Buddhist	50	24.8
	Kirat	23	11.4
	Christain	8	4.0
	Hindu	121	59.9
Occupation	Agriculture	104	51.5
	Bussiness	60	29.7
	Service	24	11.9
	Other	14	6.9

4.4 Type of salt for household consumption and for livestock

Previous surveys showed that salt for the household consumption and for livestock was separate in type in different parts of our country. Based on those facts, this study also categories salt for two different purposes: for household consumption and for livestock.

4.4.1 Type of salt consumed in households

On observation of salt sample brought by school children in school, two types of salts were found. Out of 202 salt sample 196 (97%) used packet salt and 6 (3.0%) open salt for their consumption in their households. The survey result concluded that majority of the school children consumed packet salt 196 (97%) and only 6(3%) using rough salt for household consumption which showed the greatest achievement of availability of packet salt in that Suryodaya Municipality, Ilam.

The previous finding of NMSS 1998 showed that availability of packet salt was only 3.8% in Eastern Hills (NMSS,1998) whereas the NIDDS survey 2005 reported 46.9% of study population in Eastern and central Hills used iodized packet salt (NIDDS survey, 2005). The IDD survey 2007 illuminated that the use of iodized packet salt was 29.0% in Eastern Hills (IDD survey, 2007). Our finding can be further compared with the similar study performed by Gelal *et. al* which found that majority of children used packet salt. As our result is remarkably higher than those of other survey conducted, this may be due to the underlying fact of ongoing awareness programmes of iodized salt. There has been a number of awareness programmes conducted by government agencies, NGOs and INGOs all over Nepal for using iodized salt. People are continuously being informed via electronic media, pamphlets, newspapers, hoarding board and many more about the importance of iodized salt.

4.4.2 Type of salt used for livestock in household

This observation was done in household of the school going children, where it was found that Out of 202, 34 (16.8 %) had no livestock in their households, remaining 163 (80.7%) households used open salt for livestock and only 5 (2.5%) used packet salt for their livestock. This finding is comparable with the finding of NIDDS survey, 2005 in Eastern and central Hills in which 20.4% of households used iodized salt and 44.4% used open salt for live stocks. In this study, we could see that majority of the households were using rough salt for their livestock. This was probably due to higher cost of iodized salt compared to open salt.

Table 4.4 Type of salt for household consumption and for livestock

Salt practices	Subgroup	Frequency	Percentage
Type of salt for household	Packet salt	196	97.0
	Open salt	6	3.0
Type of salt for livestock	Packet salt	5	2.5
	Open salt	163	80.7

4.5 Salt related practices in household of participants

Salt practices in household varied widely in respect to their container used for storing, place of storing in kitchen and time of adding salt in food while cooking. All these factors directly or indirectly affect the iodine content in salt and its availability for us. Majority, 126 (62.4%) added salt in food in the beginning while cooking food, only few 9 (4.5%) added at the end and rest of household added in the middle of the cooking. Most of the households 155 (76.7%) used wooden shelf to store salt while remaining kept near fire place (10.39 %/) and in window plane (12.87%). Majority of household 187 (92.6 %) used air tight container for storage of salt and 15 (7.4%) used open for storage.

Table 4.5 Salt using practices in household of participants

Salt practices	Subgroup	Frequency	Percentage
Salt container	Air Tight Container	187	92.6
	Open Container	15	7.4
Salt storage in kitchen	Window Plane	26	12.9
	Near Fire	21	10.4
	Shelf	155	76.7
Time of adding salt while cooking	Beginning	126	62.4
	Middle of Cooking	67	33.2
	At the end	9	4.5

4.6 Salt iodine content (SIC) of salt samples tested by rapid kit test.

Nepal requires that salt be iodized at a minimum of 50 ppm of iodine (85 ppm of potassium iodate) at the factory, with the expectation that the salt will retain at least a level of 30 ppm at the retail level and 15 ppm at the household level (MOHP, 2005).

According to this study, household consuming adequately iodized salt i.e. SIC >15 ppm was 93.1%, whereas 5.4% had < 15 ppm and 1.5% household were using salt having 0ppm SIC as measured by RTK. (Table no 4.6). NMSS, 1998 reported that 50.6% salt samples from the Eastern Hills had adequate iodine but NIDDS, 2005 found the only 63.4% salt samples from Eastern and Central Hills were adequately iodized (NIDDS, 2005).

Adequately iodized salt (based on the rapid test kit) was present in 77% of households in 2006 and 80% of households in 2011(MOHP, 2011).

Our study can be supported by a study performed by Gelal *et. al.* The studied school children of Dhankuta and Dharan cities of Eastern Nepal. The study found that the percentages of salt samples with adequately iodized salt (≥15ppm) were 81.3% in Dhankuta and 89.6% in dharan (Gelal *et. al.*, 2009).

It indicates that, results of our study were remarkably better than the previous national surveys. This survey result focused the reality that the most of the households in the study population used iodized salt having two child logo due to which the result of RKT showed majority samples having SIC>15ppm. Also, this study illuminated the fact that Eastern Nepal is continuously progressing towards the sustainable elimination of iodine deficiency disease as illustrated by a normal median UIE and the majority of households consuming adequately iodized packet salt.

Table 4.6 Salt iodine concentration (SIC) of salt samples tested by rapid kit test.

Statistics	**Subgroup**	**Frequency**	**Percentage**
	>15ppm	188	93.1
Iodine content of salt	<15ppm	11	5.4
	0 ppm	3	1.5

4.7 Iodine status of the school going children

WHO has categorized iodine status in five groups viz. severe deficiency (<20µg/l), moderate deficiency (20-49µg/l), mild deficient (50-99µg/l), sufficient (100-299µg/l) and excessive(>300µg/l). In total of 202 study population 3% found to severe iodine deficient, 9.9% were moderate deficient similarly 17.8% were mild deficient ,62.9% were found to have adequate UIE and 6.4% had excessive UIE.

The proportion of school children with some degree of iodine deficiency (UIE <100µg/L) is 30.7% (n=62) which is comparable (25.3%) to the all hills reported in NMSS 1998 in all Hills, 27.3% in eastern and Central Hills in NIDDS, 2005 and 18.9% in Eastern Terai in IDD survey 2007. A similar study conducted by Gelal *et. al* in school going children in Dhankuta and Dharan district of eastern Nepal found that 22.0% of study population had shown to be iodine deficient (UIE <100µg/l) (Gelal *et. al.*, 2009).

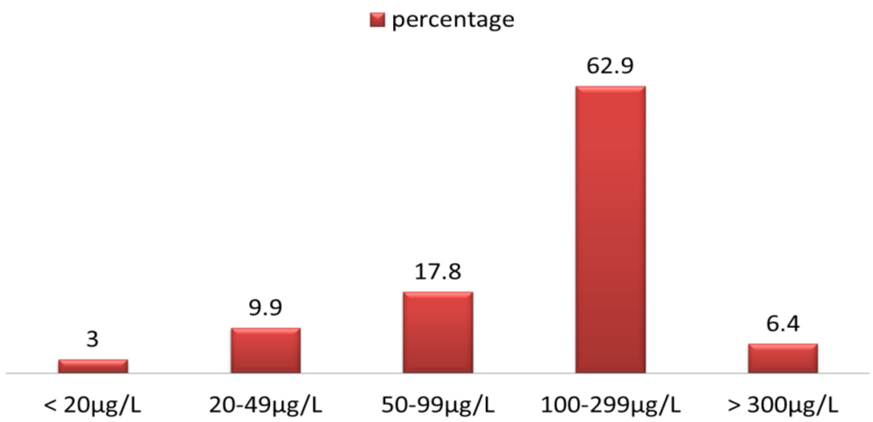


Fig. 4.1 Iodine status of school going children

4.7.1 Distribution of iodine status based on sex

Out of 121 boys, 28.1% had iodine <100 µg/L and of 81 girls,34.6% had median UIC less than 100 µg/L according to the finding of this study.

According to NMSS 1998, 33% of male and 37.2% female were iodine deficient. Similarly, in 2005, NIDDS survey 25.2% male and 29.8% female were iodine deficient. NIDDS survey 14.8 % and 15.6 % boys and girls were iodine deficient respectively.

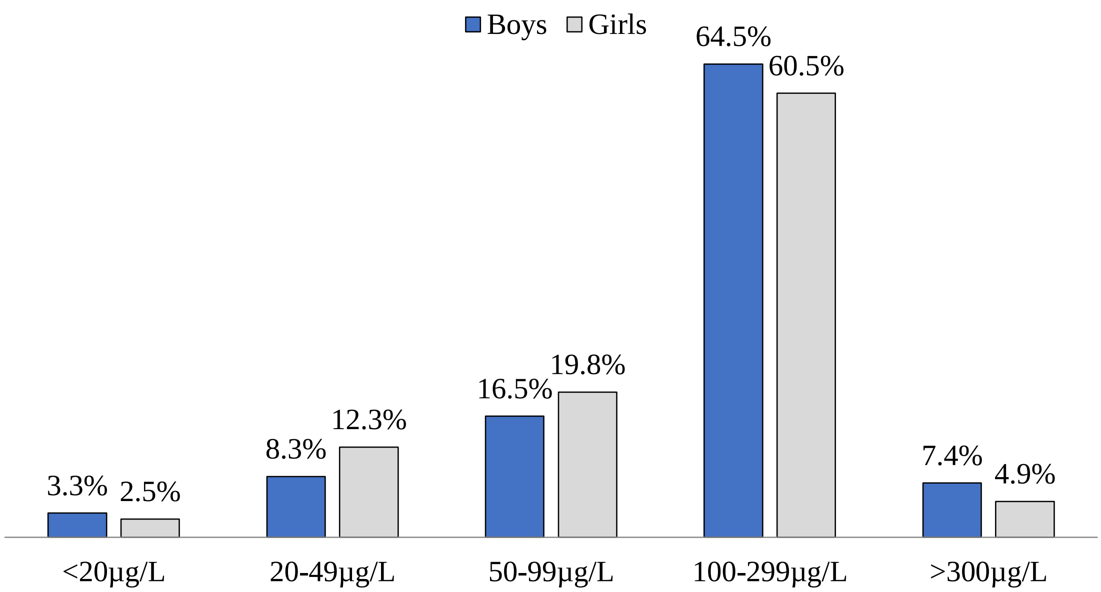


Fig. 4.2 distribution of iodine status based on sex

4.7.2 Median UIE of school going children.

The median UIE of boys was found to be 161.72 µg/L and of girls was 138.36µg/L. Overall median UIE of the study population was 152.14 µg/L which indicated the adequate iodine intake and optimal iodine status of the population. Iodine status of Suryodaya municipality, Ilam was lower than the result of national survey and the study conducted in western Nepal. This difference may be probable due to small sample size and short period of study, study area as well as due to difference in socioeconomic characteristic, and geographical characteristics of study.

The UIE were 183.0 µg/L and 204 µg/L as reported in NMSS, 1998 and NIDDS Survey, 2005 respectively in all Hills in national level (NMSS, 1998; NIDDS Survey: 2005). The IDD survey 2007 found median UIE to be 202.88 µg/l among school going children of the country (IDD Survey, 2007).

Finding of this study is consistent with the finding of the similar study conducted by Gelal *et. al* who conducted a study among 1094 school going children to evaluate iodine status of Nepalese school going children by measuring UIE The median UIE measured at national level was 193.10µg/l; indicating adequate iodine intake in Nepalese school going children (Gelal *et. al.*, 2009).

Similar study conducted by Chaudhari*et.al.* in Dhankuta and Sunsari District of eastern Nepal among primary school going children showed that the median UIE of school going children of Dhankuta and Sunsari were 238.00µg/l and 294.96 µg/l respectively (Chaudhari *et. al*.,2012).

Further similar study conducted by Gelal *et. al* in Dharan and Dhankuta cities of eastern Nepal in school going children found out that the median UIE were 157.1µg/l and 180.3 µg/l in Dhankuta and Dharan respectively (Gelal *et. al.*, 2010).

Another study performed in school going children by Joshi *et.al.* in Kavre,Parsa and Lalitpur reported the value of median UIEs were 139.00 µg/l of Kavre 266.7 µg/l of Parsa and 244.4 µg/l of Lalitpur districts of Nepal(Joshi *et. al*.,2007).

Although, the value of median UIE of present study indicated the presence of adequate iodine intake and optimal iodine nutrition; the median UIE value was notably lower than previous data. This might be due to the fact that the current study was conducted in small sample size in contrary to the sample size of the studies of which outcomes were compared.

T**able 4.7** Median UIE of school going children.

Statistics	**N**	**Mean**	**Median**	**Std. Deviation**	**Percentiles 25**	**Percentiles 75**
UIE (µg/L)	202	159.48	152.14	94.93	82.87	218.67

4.8 Factors affecting Salt Iodine Content

In this study, chi-square test analysis, it was found that there is statically significant association between salt container and SIC ($p<0.05$) i.e salt samples stored in air tight container had higher amount of iodine as compared to open container. Also same test was applied between place of salt storage and SIC, Statically significant association was found between place of salt storage in kitchen and iodine content of salt ($p<0.05$). There's a significant difference between salt iodine content in the salt samples stored in shelf as compared to the window plane and near fine. Salt container stored in shelf had higher concentration of iodine as compared to salt stored in window plane or near fire. Therefore we can conclude that we can maintain optimum iodine content of salt by placing it in air tight container inside shelf. The table no.4.8 shows, Chi-square test analysis results of factors affecting iodine content of the salt.

Table 4.8 Iodine of salt content affecting by different factors

Statistics	Subgroup	Iodine content of salt			P value*
		>15ppm (n=188)	<15ppm (n=11)	0 ppm (n=3)	
Salt container	Air Tight Container	180 (95.7%)	6 (54.5%)	1 (33.3%)	**0.001**
	Open Container	8 (4.3%)	5(45.5%)	2 (66.6%)	
Salt storage in kitchen	Shelf	152 (80.9%)	2 (18.2%)	1 (33.3%)	**0.001**
	Window Plane	18 (9.6%)	6 (54.5%)	2 (66.7%)	
	Near Fire	18 (9.6%)	3 (27.3%)	0 (0.0%)	

*Chi-square test was applied to test the significance considering p≤0.05 at 95% confidence interval

4.9 Factors affecting urinary iodine excretion

There are a number of factor by which urinary iodine concentration can be affected. The affecting factor are grouped in two different heading: demographic factors and salt using practices.

4.9.1 Demographic factors affecting urinary iodine excretion

Table 4.9.1 shows, Mann Whitney U test analysis results of factors associated with median UIE of the school going children. The Mann Whitney test revealed that the households having livestock (P = 0.015), type of salt for households (p=0.041) and religion(p=0.03) was significantly associated with median UIE. While there was no significant association between annual dietary habit (P=0.394), parent’s educational status (P=0.0327, knowing the importance of iodized salt (P=0.388), and type salt for livestock (P=0.067) with median UIE.

Table 4.9 Comparison of UIE among different demographic characteristics.

Group	Subgroup	UIE (µg/L)			P Value
		Median	Percentile 25	Percentile 75	
Dietary habit	Veg	172.95	102.52	248.44	0.394*
	Non Veg	145.17	78.75	212.09	
Education status	Literate	158.10	90.86	217.94	0.327*
	Illiterate	83.55	61.88	239.39	
Importance	Yes	149.81	88.97	209.21	0.838*
	No	160.51	72.41	233.10	
Livestock	Yes	196.61	145.17	242.59	**0.015***
	No	139.49	75.10	210.65	
Type of salt for household	packet salt	159.30	86.14	220.91	**0.041***
	Open salt	83.55	61.88	133.91	
Type of salt for livestock	packet Salt	94.69	94.69	116.74	0.067*
	Open Salt	142.88	74.20	212.09	
Religion	Buddhist	128.45	76.01	206.35	**0.030****
	Kirat	92.77	61.88	203.53	
	Christain	161.24	78.29	203.65	
	Hindu	174.15	102.52	233.10	

*Mann Whitney U test was applied to test the statistical significance between the groups.

**Kruskal Wallis test was applied to test the statistical significance between the groups

The significance level is ≤0.05

4.9.2 Salt using practices affecting urinary iodine concentration

Table 4.9.2 shows, Statistical tests analysis results of some other factors associated with median UIE of the school going children. The test showed that time of adding salt while cooking (0.301) , place of salt storage in kitchen (0.883) salt container (0.626) are not significantly associated with UIE.

Table 4.10 Comparison of UIE among different salt using practices

Group	Subgroup	UIE (µg/L)			P Value
		Median	Percentile 25	Percentile 75	
Salt container	Air Tight Container	159.30	87.07	220.91	0.189*
	Open Container	51.72	51.72	51.72	
Salt storage in kitchen	Shelf	152.15	81.49	217.94	0.883**
	Window Plane	138.39	92.77	220.91	
	Near Fire	187.14	90.86	212.09	
Time of adding salt while cooking	Beginning	158.10	76.01	223.91	0.301**
	During	159.30	94.69	212.09	
	At the End	90.86	49.71	145.17	

The significance level is ≤0.05

**Kruskal Wallis test was applied to test the statistical significance between the groups

*Mann Whitney U test was applied to test the statistical significance between the groups.

4.10 Association between SIC and UIE

This is the most important correlation to be found as this was the second objective of this study. The correlation between iodine intake (indicated by the iodine content of the salt consumed) and UIE is significant (p =0.025) UIE level increases among individuals consuming salt that contain more iodine. Similar finding was seen in NSISIDD, 2007 where linear correlation co-efficient was 0.48.the median UIE level was high among school going children from households which were consuming adequately iodized salt.

Table 4.11 Association between SIC and UIE

Statistics	**Categories**	**Median UIE**	**P Value****
	>15ppm	159.30	
Iodine content of salt	<15ppm	133.91	0.025
	0ppm	92.77	

**Kruskal Wallis test was applied to test the statistical significance between the groups

The significance level is ≤0.05

Part V

Conclusion and recommendation

5.1 Conclusion

1. In total of 202 study population 3% found to severe iodine deficient, 9.9% were moderate deficient similarly 17.8% were mild deficient, 62.9% were found to have adequate UIE and 6.4% had excessive UIE.

2. Median urinary iodine excretion indicates adequate (152.14 µg/L) iodine status of the school going children of Suryodaya municipality, Illam.

3. Majority of the school children consumed packet salt (97%) and the household with salt iodine concentration >15 ppm. was 93.1% as measured by RTK which shows the greatest achievement of availability of packet salt in that Suryodaya Municipality, Ilam.

4. The study concluded that the iodine content of the salt and UIE is significantly associated.

5. The study showed that time of adding salt while cooking, place of salt storage in kitchen and salt container are not significantly associated with UIE.

6. Salt stored in air tight container had higher amount of iodine as compared open container. Similarly, salt stored in shelf of kitchen showed higher iodine content then salt kept in window plane and near fire.

7. Findings of this study are of great importance as they identify potential actions that can be taken for the improvement of iodine status children. A number of populations at this municipality still uses crystal salt which is insufficient in iodine. Awareness about importance of iodized salt is required in areas.

5.2 Recommendation

Based on the results of this study, following recommendations could be made in order to improve the iodine status of school going children of the study area:

1. Study of this nature should be carried out at regular intervals so that it will assist the stakeholder to formulate plan and policies for the betterment of nutritional status.

2. Future studies should be aimed at finding the effect of type of salt intake and salt iodine content on thyroid function in such populations with increased sample size.

3. Public awareness program about the importance of iodine in health and disease, cause and prevention of iodine deficiency as well as about procurement, storage and proper use of iodized salt should be conducted on regular interval.

4. There is urgent need for more attention on assessing the iodine status of neonates and pregnant women so that problem of iodine deficiency can be reduced to minimum.

5. Comprehensive, integrated and multi-sectorial plan should be made for addressing the long-term consequences of IDD disorder.

Part VI

Summary

Iodine deficiency is the most common cause of preventable brain damage in childhood which is the primary motivation behind the current worldwide drive to eliminate it (WHO,2004). The prevalence of iodine deficiency in hilly and plain regions is 18.9 % and 9.5% respectively shown by previous studies (Gelal *et. al.*, 2010). The most devastating outcomes of iodine deficiency are increased perinatal mortality and mental retardation. This study was designed to study iodine nutrition status in Suryodaya municipality of Ilam by using different indicators i.e. urinary iodine excretion (UIE) and salt iodine content (SIC) recommended by WHO, ICCIDD and UNICEF.

In this study, two schools were selected by random sampling method (lottery method) out of 32 primary and higher secondary schools of Suryodaya Municipality, Ilam. All the eligible children in the age group 6 – 12 years in those schools were subjects.

Out of total 202 participants, 121 (59.9%) were boys and 81 (40.1%) were girls (Fig 1). A total of 127(62.9%) children were enrolled from Saijyoti school and 75 (37.1%) from Krishna Ma Vi. The heads of the selected schools were first briefed about the study and the permission was taken. The day of the visit was fixed in discussion with the head. The students were also briefed about the study and were asked to bring 2 table spoons (20g) salt from their houses in the polythene pouches provided on the study day. On the day of study anthropometric measurement (height and weight) along with other demographic parameters were taken and age was obtained from school record .Urine sample were collected from the children and brought to laboratory, Department of Biochemistry, BPKIHS, Dharan and stored in -20 degree centigrade for further analysis. The findings of the biochemical analysis of urinary iodine excretion levels were calculated and the iodine content of the salt was recorded. Chi Square Test, Mann-Whitney U test and Kruskal-Wallis test were used to find association between variables.

It is found that the percentage availability of adequately iodized salt was 93.1% as measured by RTK. The percentage of school children with some degree of iodine deficiency UIE <100µg/L) is 30.7% (n=62) which is comparable (25.3%) to the all hills reported in NMSS 1998 in all Hills, 27.3% in eastern and Central Hills in NIDDS, 2005 and 18.9% in (Eastern Terai in IDD survey 2007.

Median UIE of the study population is 152.14 µg/L indicates the adequate iodine intake and optimal iodine nutrition of the population which is slightly lower than that of 183.0 µg/L and 204 µg /L reported in NMSS, 1998 and NIDDS Survey, 2005 respectively in all Hills.

The study concluded that the iodine content of the salt and UIE was significantly associated. There's a significant difference between salt iodine content in the salt samples stored in shelf as compared to the window plane and near fine (p=0.001). Similarly, salt samples stored in air tight container had higher amount of iodine as compared open container (p=0.001). This survey result concluded that the median UIE of the study population indicates the adequate iodine intake and optimal iodine nutrition at the population level. Iodine status of Suryodaya municipality, Ilam was lower than the result of national survey and the study conducted in western Nepal. This difference may probable due to small sample size and short study period and difference study area, socioeconomic characteristic, and geographical characteristics of study.

The result of the work can be utilized by government as well as voluntary organization and the local government to initiate steps to tackles the existing IDD problems and encourage people for the improvement of present iodine status of their children by improving iodine supplement through feeding practices of their children. This result can also create awareness of the people about the real situation of that population responsible for the prevalence of malnutrition.

References

Andersen, S., Karmisholt, J., Pedersen, K.M. and Laurberg, P. (2008). Reliability of studies of iodine intake and recommendations for number of samples in groups and in individuals. *British journal of nutrition,* **99** (04), 813-818.

Assey, V.D., Greiner, T., Mzee, R.K., Abuu, H., Mgoba, C., Kimboka, S. and Peterson, S. (2006). Iodine deficiency persists in the Zanzibar Islands of Tanzania. *Food and nutrition bulletin*, **27** (4), 292-299.

Baral, N., Lamsal, M., Koner, B.C. and Koirala, S. (2002). Thyroid dysfunction in eastern Nepal. *Southeast Asian journal of tropical medicine and public health,* **33** (3), 638-641.

Biswas, A.B., Chakraborty, I., Das, D.K., Roy, R.N., Ray, S. and Kunti, S.K. (2006). Assessment of iodine deficiency disorders in Purulia district, West Bengal, India. *Journal of tropical pediatrics,* **52** (4), 288-292.

De Benoist, B., McLean, E., Andersson, M. and Rogers, L. (2008). Iodine deficiency in 2007: global progress since 2003. *Food and nutrition bulletin,* **29** (3), 195-202.

De Escobar, G. M., Obregón, M. J., and Del Rey, F. E. (2004). Role of thyroid hormone during early brain development. *European Journal of Endocrinology,* **151** (Suppl 3), U25-U37.

Delange, F. (2001). Iodine deficiency as a cause of brain damage. *Postgraduate Medical Journal*, **77** (906), 217-220.

DeLong, G.R. (1989). Observations on the neurology of endemic cretinism. *In*: “Iodine and the brain”. pp. 231-238. Springer US.

Dobbing, J. and Sands, J. (1973). Quantitative growth and development of human brain. *Archives of disease in childhood,* **48** (10), 757-767.

Fierro-Benitez, R., Ramirez, I., Estrella, E., and Stanbury, J.B. (1974). The role of iodine deficiency in intellectual development in an area of endemic goiter. *In:* “Endemic goiter and cretinism: Continuing threats to world health”. (J. Dunn, and G.A. Medeiros-Neto, Eds.) pp. 135-142. Washington: Pan American Health Organization

(PAHO) Scientific publ.

Gaitan, E. (1990). Goitrogens in food and water. *Annual review of nutrition*, **10** (1), 21-37.

Gelal, B., and Baral, N. (2010). Moving towards the sustainable elimination of IDD in Nepal. *IDD Newsl*, **36** (2), 12-14.

Gelal, B., Aryal, M., Lal Das, B. K., Bhatta, B., Lamsal, M., and Baral, N. (2009). Assessment of iodine nutrition status among school age children of Nepal by urinary iodine assay. *Southeast Asian Journal of Tropical Medicine and Public Health*, **40** (3), 538.

Grantham-McGregor, S., and Ani, C. (2001). A review of studies on the effect of iron deficiency on cognitive development in children. *The Journal of nutrition*, **131** (2), 649S-668S.

Hess, S. Y., Zimmermann, M. B., Arnold, M., Langhans, W., and Hurrell, R. F. (2002). Iron deficiency anemia reduces thyroid peroxidase activity in rats. *The Journal of nutrition*, **132** (7), 1951-1955.

Hetzel, B. S. (1987). The prevention and control of iodine deficiency disorders. Presented at ACC / SCN State-of-the-Art Series; Nutrition Policy Discussion Paper No. 3. pp. 123. Geneva, Switzerland, World Health Organization [WHO], Administrative Committee on Coordination, Subcommittee on Nutrition.

Hetzel, B.S., Clugston, G.A. (1999) Iodine. *In*: "Nutrition in Health and Disease" (Vol. 9). (Shils M, Olson JA, Shike M, Ross AC, Eds.). pp. 253-264. Baltimore: Williams & Wilkins.

Holmes, W., and Toole, M. (2005). Micronutrient supplements in pregnant Nepalese women. *The Lancet*, **365** (9463), 916-917.

Huda, S. N., Grantham-McGregor, S. M., Rahman, K. M., and Tomkins, A. (1999). Biochemical hypothyroidism secondary to iodine deficiency is associated with poor school achievement and cognition in Bangladeshi children. *The Journal of nutrition*, **129** (5), 980-987.

Intenational Council of Iodine Deficiency Disorders (1999). Indicator for assessing IDD status. [Newsletter] **15**, 33-8.

Joshi, A. B., Banjara, M. R., Bhatta, L. R., Rikimaru, T., and Jimba, M. (2007). Insufficient level of iodine content in household powder salt in Nepal.

Joshi, A., Banjara, M., Bhatta, L., Rikimaru, T. and Jimba, M. (2007) Insufficient level of iodine content in household powder salt in Nepal. *Nepal Medical College Journal***9** (2), 75-8

Joshi, A.B., Banjara, M.R., Bhatta, L.R., Rikimaru, T. and Jimba, M. (2006). Assessment of IDD problem by estimation of urinary iodine among school children. *Nepal Medical College Journal*. **89**, 111-114.

Kimball, O. P. (1922). The prevention of simple goiter in man. *The American Journal of the Medical Sciences*, **163** (5), 634-649.

Knudsen, N., Christiansen, E., Brandt-Christensen, M., Nygaard, B., and Perrild, H. (2000). Age-and sex-adjusted iodine/creatinine ratio. A new standard in epidemiological surveys? Evaluation of three different estimates of iodine excretion based on casual urine samples and comparison to 24 h values. *European journal of clinical nutrition*, **54** (4), 361-363.

Kochupillai, N., Pandav, C. S., Godbole, M. M., Mehta, M., and Ahuja, M. M. S. (1986). Iodine deficiency and neonatal hypothyroidism. *Bulletin of the World Health Organization*, **64** (4), 547-551.

Koutras, D., Matovinovic, J. and Vought, R. (1980). “The ecology of iodine”. Endem Goiter Endem Cretin John.

Lombardi, F.A., Pinchera, A., Antonangeli, L., Rago, T., Chiovato, L., Bargagna, S., Bertucelli, B., Ferretti, G., Sbrana, B., Marcheschi, M. and Vitti, P. (1995). Mild iodine deficiency during fetal/neonatal life and neuropsychological impairment in Tuscany. *Journal of endocrinological investigation*, **18** (1), 57-62.

McGuire, J., and Galloway, R. (1994). “World Bank. Enriching lives: overcoming vitamin and mineral malnutrition in developing countries. Development in Practice Series”. Washington DC: World Bank.

Michot, J. L., Osty, J., and Nunez, J. (1980). Regulatory effects of iodide and thiocyanate on tyrosine oxidation catalyzed by thyroid peroxidase. *European Journal of Biochemistry*, **107** (2), 297-301.

Ministry of Health & Population, Child Health Division ,Micronutrient Initiative and New Era (2005). "Nepal Iodine Deficiency Disorders Status Survey, 2005".

Ministry of Health & Population, Child Health Division, HMG/N, New Era, Micronutrient Initiative and UNICEF Nepal (1998). "Nepal Micronutrient Status Survey 1998". Kathmandu, Nepal.

Ministry of Health & Population, Child Health Division, Micronutrient Initiative and New Era (2005). "Nepal Iodine Deficiency Disorders Status Survey, 2005".

Ministry of Health & Population, Child Health Division, The Micronutrient Initiative, New Era (2005). "Iodine deficiency disorders status survey 2005 (Revised Print)". Kathmandu, Nepal.

Ministry of Health & Population, Department of Health Services, Government of Nepal, Government of India (2007). "National Survey and Impact study for Iodine Deficiency Disorders (IDD) and availability of iodized salt in Nepal".

Morreale de Escobar, G., JesúsObregón, M., and Escobar del Rey, F. (2000). Is Neuropsychological Development Related to Maternal Hypothyroidism or to Maternal Hypothyroxinemia? 1. *The Journal of Clinical Endocrinology & Metabolism*, **85** (11), 3975-3987.

Pandav, C. S., Arora, N. K., Krishnan, A., Sankar, R., Pandav, S., and Karmarkar, M. G. (2000). Validation of spot-testing kits to determine iodine content in salt. *Bulletin of the World Health Organization*, **78** (8), 975-980.

Pandav, C. S., Arora, N. K., Krishnan, A., Sankar, R., Pandav, S., and Karmarkar, M. G. (2000). Validation of spot-testing kits to determine iodine content in salt. *Bulletin of the World Health Organization*, **78** (8), 975-980.

Papanastasiou, L., Vatalas, I. A., Koutras, D. A., and Mastorakos, G. (2007). Thyroid autoimmunity in the current iodine environment. *Thyroid*, **17** (8), 729-739.

Pharoah, P. O. D., Connolly, K. J., Ekins, R. P., and Harding, A. G. (1984). Maternal thyroid hormone levels in pregnancy and the subsequent cognitive and motor performance of the children. *Clinical endocrinology*, **21** (3), 265-270.

Raveesh, P.M., Kumar, A., Boramma, G., Reddy, S. and Kapate, R. (2014). Prevalence of iodine deficiency disorders among 6-12 years school children of Gulbarga city. *Indian Journal of Community Health*, **26** (6), 166-169.

Santiago-Fernandez, P., Torres-Barahona, R., Muela-Martinez, J. A., Rojo-Martínez, G., Garcia-Fuentes, E., Garriga, M. J., Leon, A. G. and Soriguer, F. (2004). Intelligence quotient and iodine intake: a cross-sectional study in children. *The Journal of Clinical Endocrinology & Metabolism*, **89** (8), 3851-3857.

Sarkar, S., Mohanty, B., and Basu, S. (2007). Iodine deficiency in school going children of Pondicherry. *The Indian Journal of Pediatrics*, **74** (8), 731-734.

Stanbury, J. and Hetzel, B. (2007). Endemic goiter and endemic cretinism. Iodine Nutrition in health and disease. New York: Wiley. pp. 606.

UNICEF (2001). UNU/WHO. Iron deficiency anemia: assessment, prevention, and control. A Guide for Programme Managers. WHO/NIID [Report no013].

United Nations Children’s Fund (2002). Iodine Deficiency Disorders and Universal Salt Iodization: South Asia Priorities.

United Nations Childrens Fund (WHO/ICCIDD/UNICEF) (2007). “Assessment of the iodine deficiency disorders and monitoring their elimination. Geneva: World Health Organization”.

Vejbjerg, P., Knudsen, N., Perrild, H., Laurberg, P., Andersen, S., Rasmussen, L.B., Ovesen, L. and Jørgensen, T. (2009). Estimation of iodine intake from various urinary iodine measurements in population studies. *Thyroid*, **19** (11), 1281-1286.

WHO (1996).”Universal salt iodization works; quality control and monitoring are critical elements for success”. World Health Organization, Geneva, Switzerland.

WHO (2004). “Iodine status worldwide: WHO global database on iodine deficiency”. Geneva, World Health Organisation.

WHO (2012). Micronutrient Deficiencies.

WHO, UNICEF, IDA (1998). Prevention, Assessment and Control. Report of joint WHO/UNICEF/UNU consultation [Report]. Geneva.

WHO,UNICEF, ICCIDD (2007). Assessment of iodine deficiency disorders and monitoring their elimination: a guide for programme managers. France.

WHO,UNICEF, ICCIDD. Assessment of iodine deficiency disorders and monitoring WHO (1994). Iodine and health: eliminating iodine deficiency disorders safely through salt iodization, a statement by the World Health Organization. p.p. 7

World Health Organization, International Council for the Control of the Iodine Deficiency Disorders and United Nations Childrens Fund (WHO/ICCIDD/UNICEF) (2007). “Assessment of the iodine deficiency disorders and monitoring their elimination”. Geneva: World Health Organization.

Zimmermann, M. B. (2006). The influence of iron status on iodine utilization and thyroid function. *Annu. Rev. Nutr.*, **26**, 367-389.

Zimmermann, M. B., Connolly, K., Bozo, M., Bridson, J., Rohner, F., and Grimci, L. (2006). Iodine supplementation improves cognition in iodine-deficient schoolchildren in Albania: a randomized, controlled, double-blind study. *The American journal of clinical nutrition*, **83** (1), 108-114.

Zimmermann, M. B., Connolly, K., Bozo, M., Bridson, J., Rohner, F., and Grimci, L. (2006). Iodine supplementation improves cognition in iodine-deficient schoolchildren in Albania: a randomized, controlled, double-blind study. *The American journal of clinical nutrition*, **83** (1), 108-114.

Zimmermann, M. B., Jooste, P. L., and Pandav, C. S. (2008). Iodine-deficiency disorders. *The Lancet*, **372** (9645), 1251-1262.

Zimmermann, M. B., Wegmüller, R., Zeder, C., Chaouki, N., and Torresani, T. (2004). The effects of vitamin A deficiency and vitamin A supplementation on thyroid function in goitrous children. *The Journal of Clinical Endocrinology & Metabolism*, **89** (11), 5441-5447.

Zimmermann, M., Adou, P., Torresani, T., Zeder, C., and Hurrell, R. (2000). Persistence of goiter despite oral iodine supplementation in goitrous children with iron deficiency anemia in Cote d'Ivoire. *The American journal of clinical nutrition*, **71** (1), 88-93.

Zimmermann, M.B., Wegmueller, R., Zeder, C., Chaouki, N., Rohner, F., Saïssi, M., Torresani, T. and Hurrell, R.F. (2004). Dual fortification of salt with iodine and micronized ferric pyrophosphate: a randomized, double-blind, controlled trial. *The American journal of clinical nutrition*, **80** (4), 952-959.

Appendices

Appendix - A

Survey Questionnaire   Date of Interview: 2073/

A. General Information

1. Name of head of household:

2. Ward No.:

3. Respondent: Mother   Father   Other Family Members

4. What is number of family members in your household?

5. What is the education status of the head of the household?

a) litterate   b) Illitrate

6. What is your religion?

a) Buddhist b) Kirat c) Christian d) Hindu

7. What is the main income source of your family?

a) Agriculture b) Business   c) service   d) others

8. How many month of the year is the family income sufficient to fulfill the needs of family members?

9. Do you have any livestock in your household?

a) Yes   b) No

10. Have you heard about iodized salt?

a) Yes   b) No

11. Do you know about importance of iodized salt?

12. What type of salt do you use in your family?

13. What type salt you use for your livestock?

14. How much do you pay for one kg salt?

15. What is the frequency of buying salt for household?

a) once a week b)once in two week c) once a month d) don’t know

16. Which time do you add salt at the time of cooking?

a) at the beginning b)during cooking c)at the end of cooking

17. What is the place of storing salt in the kitchen?

a) near stove b) on window c) on shelf d) others

18. What is the type of container you use for storing salt?

a) Open container b) air tight container c) others

19. Why don’t you use salt having two child logo?

a) expensiveness b)not found c) don’t like d)don’t know

20. Are you a non;vegeterian in diet?

21. Most of time which type of non-vegetarian diet you prefer and how many time in a week do you take?

a) fish b) chicken c) mutton d) others

22. What is the frequency of consumption of vegetable like brocauli, cauli flower, cabbage, mustard leaf, radish etc?

a) Commonly consumed b) uncommon

Consentletter

Nameste!

I Mr. PrajaAdhikari, graduate student in Department of Nutrition and Dietetics conducting a dissertation work for award of bachelor"s degree in Nutrition and Dietetics.

The topic for the study is "Assessment of iodine status of the school children of Suryodaya municipality, Ilam."

I have been told in a language which I understand that , me and my son/daughter's participation is voluntary as a study subject in this study and I have been informed that my child will be asked for 5-10 ml of urine for iodine estimation and will also be asked for 15-20 gram of salt that has been using in my house. She has told that I will be also asked some informative questions about iodine. I have been stated that this is only for academic purpose and confidentiality of the result will be maintained and only be shared for academic purposes. I here by give consent to participate in the above study and also equally aware that my child reserves the full right to withdraw from the study at my own initiative at any time without having to give reason. I can withdraw this consent at any later date, if I wish to. This consent form being signed voluntarily indicates participate in the study until I decide otherwise.

Signature of parent/guardian: ___________

Date: Place:

I hereby state the study procedures were explained in the detail and all questions were fully and clearly answered to the above mentioned participant /his/her relative.

Investigator's sign: Date:

Appendix - B

Map of survey site (suryodaya municipality)

Photo gallery (clicks of data collection)

1

2

3

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Index

1. Measuring weight
2. Measuring height
3. Salt sample collection

4. Urine sample collection

5. Using sealing cassette

6. Using multipipette