ADDIS ABABABA UNIVERSITY

COLLEGE OF NATURAL AND

COMPUTATIONL SCIENCE

CENTER FOR FOOD SCIENCE

AND NUTRITION

ZINC STATUS AND ASSOCIATED FACTORS AMONG PREGNANT WOMEN AT NIFAS SILK LAFTO SUBCITY, ADDIS ABABA

BY:- GEMECHU JOFIRO

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Abbreviations and Acronyms

AAU	Addis Ababa University
ANC	Anti-Natal Care
ANOVA	Analysis of Variance
AOR	Adjusted Odd Ratio
BMI	Body Mass Index
CI	Confidence Interval
COR	Crude Odd Ratio
CRP	C - reactive protein
DD	Dieter Diversity
DDS	Dietary Diversity Score
DNA	Deoxyribonucleic Acid
EAS	Emission Absorption Spectrometry
FFQ	Food Frequency Questionnaire
FGR	Fetal Growth Restriction
HTN	Hypertension
IDDS	Individual Dietary Diversity Score
IZiNCG	International Zinc & Nutrition Consultative Group
LBW	Low Birth Weight
MUAC	Mid Upper Arm Circumference
PPM	Parts Per Million
RNA	Ribonucleic Acid
SGA	Small Gestation Age
SPSS	Statistical Package for Social Science
UNICEF	United Nation Children's Fund
WHO	World Health Organization
Zn	Zinc

Abstract

Background: Zinc is important for normal human physiology and plays great role in cell growth, reproduction and immune system from inside utero until puberty. The element is especially needed during pregnancy for fetal growth. However, globally about two billion people are zinc deficient. Populations in developing countries are at special risk of zinc deficiency associated to poor diet. Only limited studies are available in Ethiopia reporting zinc nutritional status of pregnant women. In addition, factors associated to low zinc concentration need to be identified to develop optimal intervention. This study determines serum zinc concentration among pregnant women in selected health settings in Addis Ababa. In addition, it attempts to identify significant factors for low serum zinc in the study subjects.

Methodology:- Institutional based cross-sectional study was carried out among pregnant women (n=226) in Addis Ababa. Information such as socio-demographic characteristics, anthropometric characteristics, dietary diversity, and obstetric history were collected from study participants. In addition, serum zinc concentration and C - reactive protein level were determined. Furthermore, hemoglobin concentration of pregnant women was measured. Statistical analysis was done using logistic regression methods. P-value < 0.05 at 95% confidence interval was considered statistically significant.

Result: The prevalence of zinc deficiency among pregnant women was 32.1% and media value of 90.5μg/dl. Age range of participating women was 15-42 years with mean of 25.1 ± 4.4 years. High prevalence (37.6% vs 22.8, p= 0.026) of zinc deficiency was observed among multigravida mothers when compared to prim-gravida women. Nearly three fourth (73.1%) of participating women had normal body mass index with mean value of 21.8 ± 3.1 kg/m^2. Majority, (95.8%) of the present study participants ate starch foods group. About (52.8%) of the pregnant women had medium dieter diversity score 24hrs preceding the survey with mean value of 4.9 ± 1.1. One in ten (10) of the present study women were anemic. Pregnant women who had medium dietary diversity score reduced by 92% likelihood of zinc deficiency than those who had high dietary diversity score (AOR: 0.075, P: <0.001).

Conclusions:- The prevalence of zinc deficiency among pregnant women was remain high. The dietary diversity of the study women was dominated by starch foods group. Most of the pregnant women had medium dieter diversity score. Maternal serum zinc level was significantly associated with monthly income, C-reactive protein level, and trimester, number of parity, dietary diversity score and animal source foods. Pregnant women has better to intake zinc rich animal source foods.

1. Introduction

1.1. Background and Justification

Zinc (Zn) is an essential trace element for humans, special during Pregnancy (Brown & Hess, 2009). It is complexes with organic molecules and modifies the three-dimensional structure of nucleic acids and specific proteins. Zinc has wide range of biochemical functions being part of over 200 metallo-proteins influencing the catalytic properties of many enzymes. It is important for normal cell development, maintenance of the immune system, maintains blood sugar levels, normal functions of the gonads and maintains the integrity of cellular membranes (Brown & Hess, 2009; Gibson, 2017; Ennes Dourado Ferro & et. al., 2011).

However, globally, about two billion of people are at risk of zinc deficiency (Hagmeyer, Haderspecrk, and Gabrucker, 2014). The distribution of zinc deficiency is highly variable, the least developing regions being affected the most. About 4-7% of population in North America and Europe have zinc deficiency while 25-52% of the population in North Africa & Eastern Mediterranean. In addition, 37-62 % of populations Sub-Saharan Africa and 34-73% in South & Southeast Asia are zinc deficient (Caulfield, Black, 2009). Different literatures also reported of zinc deficiency in (65%) India, (60%) Peru, (24%) Iran, (22%) Indonesia, (29%) Vietnam and (14.7%) Bangladesh (Frost & Sullivan, 2008). Zinc deficiency is also a public health problem in Ethiopia. A study conducted in rural Sidama found low serum zinc in 76% of pregnant mothers (Gebremedhin, Enquselassie & Umeta, 2011). In addition, other study conducted in Addis Ababa reported that about 39.5% of pregnant women had low serum zinc concentration (Regassa, 2017).

Zinc deficiency in pregnant women has been associated with a wide range of effect including lowering protein synthesis, cellular division and thus has potential impact on pregnancy outcomes (King, 2000). According to Global and the regional child mortality and burden of disease reported, in five countries including Ethiopia, about 47% of child death is attributed to maternal zinc deficiency during pregnancy which is cause low birth weight, congenital anomalies and retarded fetal growth, and also again highly associated with development of cardiovascular diseases, poor neurobehavioral development and several metabolic syndromes during adulthood (Walker, Ezzati, & Black, 2009). In addition, maternal zinc deficiency during pregnancy has serious complication on child hood like impairment of physical growth, immune competence, reproductive and cognitive function (Severi, Hambidge, Krebs, Alonso & Atalah, 2013). And also zinc deficiency has been associated with complications like prolonged labor and delivery, hypertension (HTN), placental abruption and premature delivery (Gibson, 2017). Zinc deficiency during adolescence can lead to delayed puberty (Shah, & Sachdev, 2001). A decrease in zinc nutrition could cause a decrease in insulin response which in turn destabilizes blood sugar levels. Decrease in adequate zinc levels create a decrease in metabolic rate. Low levels of zinc are also associated with impaired thyroid metabolism, despite of adequate iodine nutrition. This is because zinc is essential in assistance of iodine to secrete thyroid hormone (DiSilvestro, 2004). Lack of zinc also causes poor retina and macula functioning and its level in the retina decreases with age also impacting vision (Gibson, 2017).

Symptoms of zinc deficiency are poor appetite, impair of taste and smell, slow wound healing, hair loss, impaired cell-mediated immunity, depression, diarrhea, lethargy (Gibson, 2017; Roohani, Hurrell, Kelishadi, & Schulin, 2013). Children and mothers are commonly considered as vulnerable groups for zinc deficiency. The process of developing zinc storage happen during the third trimester of pregnancy leaving preterm infants in particular at risk of zinc deficiency (Roohani, Hurrell, Kelishadi, & Schulin, 2013). In addition, on the reason that breast milk can no longer provide adequate zinc beyond six months and commonly complementary foods is zinc deficient, hence infants older than six months are affected by zinc deficiency. In pregnant women the newly synthesized fetal and maternal tissue during pregnancy imposes additional physiological requirements for zinc since the fetus require high levels of zinc (Severi, Hambidge, Krebs, Alonso & Atalah, 2013).

Zinc deficiency claims 0.5 million maternal deaths in developing countries annually (Caulfield & Black, 2009). Maternal zinc deficiency is attributed to several risk factors including low intakes of animal foods, high intake of phytate contain foods, chronic infections during pregnancy (Uriu-Adams, & Keen, 2010), intake of foods high in calcium and polyphenols (Kim, Pai & Han, 2011), coffee, and poor socio-economic status (Mishra, & Gupta, 2011). In addition, increasing need of zinc by the body to meet physiological demand, excessive diarrhea or infection and defective zinc utilization by the body is considered potential risk factors (Berni Canani, Buccigrossi, & Passariello, 2011). Ethiopia Demographic and Health Survey (EDHS, 2011) reported about 44% of the under five children are stunted which is a proxy indicator of the magnitude of zinc deficiency in the country. Pregnant women are facing zinc deficiency more than the other groups due to physiological changes that require an increased zinc to accommodate normal zinc demand which result complicate pregnancy outcomes and delivery (Seshadri, 2001).

Few studies attempted to identify associated risk factors related to prenatal zinc deficiency in Ethiopia. The commonly indicated risk factors are dietary (Caulfield & Black, 2009), morbidity, demography (Kumera & Awoke, 2015) and socio-economic status (Gebremedhin, Enquselassie & Umeta, 2011). In addition, available studies more concentrate on zinc status of women and children from rural areas because of urban area women have more socially and economical advantageous, have better access of health service and knowledge toward causes of zinc deficiency (Kumera, & et.al., 2015). However, as studies are few, they are not conclusive. Therefore, this study was focused on to assess the prevalence and associated factors of zinc deficiency in pregnant women from Addis Ababa.

2. Objectives

2.1. General Objective

To assess serum zinc level and identify associated factors to low serum zinc concentration among pregnant women at selected health centers in Addis Ababa, Ethiopia.

2.2. Specific objectives

- ✓ To determine prevalence of zinc deficiency among pregnant women at selected health centers in Addis Ababa.
- ✓ To identify associated factors to low serum zinc concentration among pregnant women at selected health centers in Addis Ababa.

3. Literature Review

3.1. Zinc Distribution, Bioavailability, Metabolism and Absorption

Zinc is present in all body tissues and fluids which account about 2gm. From the total body content about 60% of zinc content is found in skeletal muscle (bone mass) while 30% is in lean body mass. Only 0.1% of total body zinc content is found plasma cell. Addition, high concentrations of zinc are found in the prostatic fluids 300-500 mg/l and choroid of the eye 274 μg/g (Hambidge, Huffer, Raboy, Grunwald, Westcott, Sian & et al., 2004).

Zinc concentration in plasma is doing not indicate total body zinc stores reliably because of concentration of zinc in tissues (muscle and liver) is 50 times greater than that in plasma. Catabolism of zinc from muscle tissue during starvation increases amount of zinc in plasma (Henry & Elmes, 1975) while consumption of standard meals like glucose, the level of zincs in plasma is decline (Hambidge, Huffer, Raboy, Grunwald, Westcott, Sian & et al., 2004).

The decline in plasma zinc concentration during pregnancy is considered a physiological response to pregnancy, due to hemo-dilution, hormonal changes, increased urinary zinc excretion, increased zinc uptake by maternal tissues, and active maternal-fetal transfer of zinc (Swanson, King, 1983). On the other hand, excretion is through endogenous intestinal (0.5 - 3 mg/day), kidneys (0.5-0.7mg/day) and skin(0.5-0.7mg/day) and zinc is also released through pancreatic juice, gastrointestinal secretions, urine, menstrual flow, semen, sloughed skin, nails, and hair (King, 2000).

The distribution of zinc among the various blood components changes during pregnancy. During late pregnancy serum or plasma zinc concentration decline by 15%–35% when compare to pre-pregnancy or early pregnancy concentration. This decline in plasma zinc levels is related to the plasma volume expansion, which increases about 40% by 30 weeks gestation (King, 2000).

Also during pregnancy erythrocyte zinc concentrations increase by 10%–15% with erythrocyte volume because of during pregnancy an increased synthesis of the zinc-dependent enzyme, carbonic anhydrase, to ensure metabolism of the carbon dioxide produced by the developing fetus (Caulfield & Black, 2009).

The total zinc mass in the plasma and erythrocytes is higher in pregnant women than in non-pregnant women, because of during pregnancy increase plasma and erythrocyte volume (Caulfield & Black, 2009). Absorption of zinc occurs inside small intestine which depends on amount of food content and zinc concentrations. Zinc absorption is varies that depending on zinc content and diet composition. So that aqueous solutions form more fast absorption than solid form (Sandström, 1997).

3.2. Biological Function of Zinc

Zinc has critical roles in cell division, differentiation and function that are essential for tissue growth and development (Maret, 2009). Zinc-dependent enzymes, zinc-binding factors and zinc transporters are required in a variety of complex mechanisms during cell replication, maturation and adhesion like DNA and ribonucleic acid (RNA) metabolism, signal recognition and transduction, gene expression, and hormone regulation (Shah, & Sachdev, 2001).

Well fetal growth and development affected by malnutrition particular during pregnant that may result to damage and decrease children cognition ability and neuropsychological as negative impact (Abebe, Bogale, Hambidge, Stoecker, Arbide, Teshome & et al., 2007). Zinc is special effect on fetal brain development during pregnancy and birth outcomes. Its deficiency potential to result cognitive deficits, affected attention and impaired working memory of brain that associated with the hippocampus (Blair, 2006).

Zinc had great role on reproductive function, especially during pre and post natal used for rapid cell growth, cellular differentiation and turnover (King, 2000). It plays a central role in the immune system and affecting a number of cellular and humoral immunity (Shankar & Prasad, 1998).

The clinical features of severe zinc deficiency in humans are growth retardation, delayed sexual and bone maturation, impaired taste, decrease wound healing, skin lesions, diarrhea, alopecia, impaired appetite, increased susceptibility to infections mediated via defects in the immune system, and the appearance of behavioral changes (Shankar, & Prasad, 1998). Zinc is prevalent in the brain, where it binds with proteins and there by contributes to the structure and function of the brain (Friel JK., Andrews, Mathew, Long, Cornel, McKim & Zerbe, 1993).

3.3. Prevalence of Zinc Deficiency during pregnancy

Globally, about two billion of people are at risk of zinc deficiency (Hagmeyer, Haderspecrk and Gabrucker, 2014). The distribution of zinc deficiency is highly variable, the least developing regions being affected the most. About 4-7% of population in North America and Europe have zinc deficiency while 25-52% of the population in North Africa & Eastern Mediterranean. In addition, 37-62 % of populations Sub-Saharan Africa and 34-73% in South & Southeast Asia are zinc deficient (Caulfield & Black, 2009). Different literatures also reported 65% of zinc deficiency in India, 60% Peru, 24% Iran, 22% Indonesia, 29% Vietnam and 14.7% in Bangladesh. Substantial burden has also been reported in developed countries like Sweden (18%) (Frost & Sullivan, 2008).

A study carried out among women in Nepal reported about 75% of reproductive age group females had zinc deficient. This was related to adverse poor pregnancy outcomes and prevalent risk of infections (Akhtar, 2013). Several studies illustrated extremely high prevalence of zinc deficiency amongst pregnant women. Based on estimated zinc intakes, Caulfield et al (2009) concluded that worldwide about 82% of the pregnant women are likely to have inadequate zinc intake.

There are limited reports on national prevalence of zinc deficiency in Africa rather the only existing country specific information is the estimate from IZiNCG which is not based on serum data (Hotz, & Brown, 2004). According to the estimate, all people of Africa countries are either in high or intermediate risk category for zinc deficiency. Ethiopia was also classified into the intermediate risk group (Walker, Ezzati & Black, 2009). Pocket studies from Nigeria 45.8% (Ugwuja & et. al., 2010), Malawi 36% (Gibson, 2017), Cameroon 82% (Engle-Stone & et. al., 2014), Eastern Sudan 38% (Mohamed & et. al., 2011), and Kenya 66.9% (Swanson, & King, 1983) reported zinc deficiency in pregnant women.

The limited available data suggest that zinc deficiency is public health concern in Ethiopia among pregnant women (Getahun, Urga, Ganebo, & Nigatu, 2017). In Ethiopia, few studies determined the prevalence of zinc deficiency in pregnant women and obtained results ranging from 53 to 76% (Kumera & et. al., 2015). All studies consistently indicated that zinc deficiency is public health significance in the country.

3.4. Consequences of Zinc Deficiency during Pregnancy

3.4. 1. Consequences of Zinc Deficiency on the Mothers

Zinc deficiency during pregnancy has different adverse effect on pregnant outcomes. Spontaneous abortion complication is resulting from early separation of placenta from uterus wall which related with zinc deficiency (Scholl, & et. al., 1993).

Other complications during pregnancy like preterm delivery, still birth and fetal neural tube defects result due to inadequate maternal zinc level. Low zinc status of pregnant women has been associated with poor pregnancy outcomes without acrodermatitis that result prolonged labor (Simmer & Thompson, 1985). Addition, zinc deficiency during pregnancy is significantly associated with maternal complication like pregnancy induced hypertension (Tamura, Goldenberg, Johnston & DuBard, 2000).

3.4. 2. Consequences of Zinc Deficiency on the Fetus

Severe maternal zinc deficiency increases fetal death due to multiple congenital anomalies of the heart, lungs, brain, urogenital system and skeletal system were very common. These malformations result from an abnormal synthesis of nucleic acids and protein, impaired cellular growth and morphogenesis, abnormal tubulin polymerization, chromosomal defects and excessive lipid peroxidation of cellular membranes (King, 2000).

One of the fetal consequences of zinc deficiencies is fetal growth restriction (FGR) during pregnancy, which result as low birth weight outcomes or manifested small for gestational age, intrauterine growth retardation, fetal death or still birth (Akhtar, 2013).

Recently study by Hua et. al (2015) conducted in China shown that there is significant association between zinc level during pregnancy and the risk of small for gestational age (SGA) of fetus. A number of fetuses for SGA seen among low zinc level (15.0%) than normal zinc level (8.2%) mothers. At early gestation age of pregnancy less number of fetuses for SGA among normal zinc level (8.3%) mothers when compared with low zinc level (22.6%) mothers. Also during later gestational stages or second and third trimesters of pregnancy less present of SGA occurred among normal zinc level (8.1%) than inadequate zinc level (13.9%) mothers.

Low birth weight (LBW) one of the serious risk factors for health problems with consequence for long term disability and various physical morbidities and mortality on pediatric age group (Osrin & Costello, 2000). In low income countries the main causes of low birth weight is due to poor nutrition during pregnancy of mothers (Klein, 2002).

3.5. Associated Risk Factors of Zinc Deficiency during Pregnancy

Global, in developing country about 0.5 million maternal deaths occurred per year due to zinc deficiency (Black, Allen, Bhutta, Caulfield, de Onis, Ezzati & et al., 2008). These results from inadequate frequently daily intake of zinc-rich animal source foods, to intake of high contain phytate food like cereals which limits zinc absorption, fiber food which decrease the zinc bioavailability and starchy roots and tubers that have low zinc content (Abebe & et al., 2007). Chronic infections during pregnancy slightly decline maternal plasma zinc concentrations that result to reduce placental zinc transport and the fetal zinc supply (Liao, & et al., 2011). In addition, calcium and polyphenols are inhibitors of bioavailability of zinc concentration (Kim, Pai & Han, 2011).

In developing countries the main factors that leading zinc deficiency is inadequate intake of zinc dietary foods with increase zinc requirements like poor absorption, enhances of zinc losses through diarrhea, improperly utilization of zinc by the body and consumption of high plant-based diets are also playing a vital role and highly significant association with zinc deficiency (Berni Canani, Buccigrossi & Passariello, 2011).

Serum zinc concentration is independently affected by acute inflammation or infection, Diurnal variation and fasting. During acute infection time redistribution of zinc from the plasma into the tissue, that result to affect and decline of serum zinc concentrations. Immediately after meal initial increases serum zinc level followed by gradual decline. During overnight fasting the zinc concentration steady increasing to reach highest level in the morning (Gebremedhin, Enquselassie & Umeta, 2011).

Study conducted in Pakistan (2011) shown that from 791 pregnant women, about 48.3% pregnant mothers affected by zinc deficiency. This was due to mainly dietary staples of less zinc content intake (Akhtar, 2013). Studies conducted to assess zinc deficiency among pregnant women in Nigeria indicated about 45.8% have zinc deficiency which related with low intake of meat, dairy product, nuts and vegetable (Ugwuja, Akubugwo, Ibiam, Obidoa, & Ugwu, 2010). In addition, study in Kenya reveals that the prevalence of zinc deficiency during pregnancy was 66.9%, which negatively associated with number of parity (NDUTAH, 2013).

In Ethiopia, study conducted in Sidama zone reported maternal zinc deficiency was (72%) which related with low protein diet intake, more consumption of cereals and starchy tubers such as enset (false banana) which has low zinc content and inhibit zinc absorption (Abebe & et al., 2007). In addition, another study conducted at rural Sidama zone zinc deficiency was 53% which associated with socio-demographic, dietary and health care service. The main causes of dietary factors were house hold food insecurity, low dietary diversity, inadequate consumption of animal source foods, and age of mothers, parity numbers and maternal education levels (Gebremedhin, Enquselassie & Umeta, 2011).

Furthermore, a study conducted in Gondor the maternal zinc deficiency was 57.4 % which influenced by socio-demographic, close birth interval, low intake of animal foods, low dietary diversity and lack of awareness about benefit balanced diet (Kumera, & et. al., 2015).

3.6. Etiology of Zinc Deficiency during Pregnancy

The etiology of zinc deficiency may be dietary, physiologic, and also health related factors. Dietary deficiency can be due to low zinc in foods consumed or low bioavailability due to the presence of anti-nutrient interfering zinc absorption or combinations of these dietary factors (Gibson, 2017).

Low intakes of dietary zinc are commonly associated with low energy intakes that caused by food insecurity in many low income countries. Inadequate intake of animal source foods, caused by economic or religious problems, may also contribute to low zinc intakes. This is because meat, poultry, and fish are rich sources of readily absorbable zinc. In some geographical areas, low soil zinc concentrations may cause lower zinc content of staple foods (DiSilvestro, 2004; Kumera, Awoke & et. al., 2015).

In many low income countries, most of their staples diets are derived from plant-based foods thus are prone to zinc deficiency. Plant-based foods contain high amount of phytic acid which is the major storage form of phosphorus in legumes that chelate minerals such as zinc. It is the major storage form of phosphorus in legumes and cereals is the only considerable dietary factor that inhibits zinc absorption, especially when foods are low animal food sources (Gibson, 2017 & NDUTAH, 2013).

Amounts of phytate and zinc and their molar proportion in the foods is proxy indicate of zinc bioavailability in the diets. Diets with phytate/zinc molar ratio greater than 15 are decline bioavailability of zinc absorption by 15%. Diets like a cereal based with low intake of animal sources are found to be in this range. Diets with phytate/zinc molar ratio range of 5-15 are a medium (30%) bioavailable of zinc absorption. Diets that classified into this category are mixed diets and vegetarian whose diets include milk or milk products and eggs. Diets with molar ratio <5 are high (50%) zinc bioavailability & absorption, which includes diets derived from animal sources and diets with low quantity of fiber (Kumera, Awoke, & et. al., 2015). Content of phytate can be decreased using food processing methods such as soaking, fermentation and germination (Gibson, 2017 & NDUTAH, 2013).

Soaking:- to decrease the phytate content of certain cereals and legumes by soaking method. About 10-70% of phytate in these staples is stored in water soluble form and removed by diffusion.

Fermentation: - is induces phytate hydrolysis through the action of microbial phytase which can be come either from the micro flora on the surface of the seeds or by introducing with microbial starter.

Germination of seeds:- is an acting of seeds to germinate for 2-3 days that can enhance the breaking of phytate by 23-88%, which affected by grain (Gibson, 2017 & NDUTAH, 2013).

Several non-nutritional importance may also be contributed by community based dietary mechanisms such as empowerment of women, training and income generation .To be seen successful this strategy.

It needs major changes in attitudes and food–related behaviors and practices that needed for effective behavior change and communication. In addition, it must be work with ongoing national agriculture, food, nutrition and health education programs and implemented using participatory approach to ensure their acceptability, adoption, and sustainability (Gibson, 2017; Hemalatha, Platel, & Srinivasan, 2007). Pregnancy results in an elevation of plasma volume and lowered levels of circulating-binding proteins thus is a risk factor for zinc deficiency suggesting additional zinc nutrition during this time is necessary. If pregnant mother do not get this increased requirement for zinc during pregnancy the body cannot accommodate normal zinc demand and its deficiency could affect pregnancy out comes and delivery. In many low-income countries, high physiologic changes can be aggravated by under nutrition, resulting into micronutrients deficiency like zinc. In pregnant women, moderate to severe zinc deficiencies is increased risk of low birth weight, pregnancy complications and birth defects (Getahun, Urga, Ganebo, & Nigatu, 2017, & Seshadri, 2001).

3.7. Dietary Sources and Daily Requirements of Zinc

Dietary pattern of food staffs had highest concentrations of zinc 25-50 mg/kg are lean red meat, whole-grain cereals, pulses, and legumes, moderate concentration of zinc 10-25 mg/kg are polished rice, processed cereals and lean meat or meat with high fat content, mild concentration of zinc <10mg/kg are fish, roots and tubers, green leafy vegetables, and very low Zn content are fruits, separated oils, sugar, and alcohols (Gibson, 2012). Daily requirement of zinc for pregnant women have been depend on amount of zinc accumulated in maternal and embryonic or fetal tissues. About 5-7% of zinc is needed for pregnancy women more than non-pregnancy women (Sandström, 1997).

According to National Academy of Sciences, Institute of Medicine, Food and Nutrition Boards in USA (2001) reported that animal protein based foods are predominated for zinc concentration than plant source foods. Zinc rich animal source foods include meat, poultry and fish. In addition the plant source foods are also described as the following table 1.

Table 1:- Dietary Sources of Zinc

Food Groups	Food Types	Zinc (mg/100g)
Cereal Food items	Maize flour (refined)	1
	Maize flour (unrefined)	2.5
	Sorghum	1.3
	White rice	1.6
	Wheat	2.7
	Millet	1.7
Legumes	Groundnuts	2.8
	Soya beans	4.9
	Kidney beans	3.2
	Pigeon peas	2.5
Leaves	Pumpkin leaf	0.7
	Okra leaf	1.8
Roots, tubers	Sweet potato	0.3
Plantains	Cocoyam	0.5
	Banana	0.9
	Plantain	0.2
	Cassava	0.3

Table 2:- Daily Requirement and Maximum Dose of Zinc intake by Life Stage (Australian Government National Health and Medical Research Council, 2014).

Age	Daily requirement (mg/day)	Upper level intake (mg/day)
Infants in Months		
0-6months	2	4
7-12 months	3	5
Children and adolescents		
1-3 years	3	7
4-8 years	4	12
9-13 years	6	25
14-18 years	7	35
Adults 19+ years		
Men	14	40
Women	8	40
Pregnant women		
14-18 years	10	35
19-50 years	11	40
Lactate Mothers		
14-18 years	11	35
19-50 years	12	40

Zinc overtaking may result poisoning or toxicity sign like nausea, vomiting, diarrhea, fever and lethargy and can be observed after ingestion over dose (Blai, 2006). In addition, long-term zinc intakes higher than the daily requirements could interact with the metabolism of other trace elements like Copper, which affects copper status, such as CuZn-superoxide dismutase in erythrocytes and anemia (Yadrick, Kenney, & Winterfeldt, 1989). On the other hand excessive intakes of zinc can change in serum lipid pattern and immune response (Hooper, Visconti, Garry, & Johnson, 1980).

3.8. Strategies to Address Zinc Deficiency

Zinc supplementation during pregnancy significant improves birth length and decrease incidence of preterm labor. Most of studies finding a positive effect of maternal zinc supplementation on infant birth weight, decrease infections, increases maturity (Ota & et al., 2015), reduced risk of preterm birth (Hess & King, 2009) and had longer gestational ages, larger head circumferences than those in the placebo group (Danesh, Janghorbani & Mohammadi, 2010). In addition, a study in the Chile among pregnancy women reported supplemented of zinc is increased birth weight and head-circumference of infant significantly and association with anthropometric indicators (Khadem1, Mohammadzadeh, Farhat, Valaee, Khajedaluee & Parizadeh, 2012). On the other hand, early initiation of zinc supplementation effect on birth weight is greater than the second or third trimester initiation (Allen, de Benoist, Dary & Hurrell, 2006.)

Food fortification approach is aims to address food insecurity in lower-income countries (Harvest Plus research and implementation, 2017). There are many methods for zinc fortification programmers, including selection of the food vehicle(s), selection of the form of zinc fortification, determining the level of zinc fortification and cost for fortification were programmed (Hambidge, Huffer, & et al. 2004).

Bio fortification is another approach to checking micronutrient deficiencies in developing countries. This intervention involves agricultural, agronomic, or genetic means to boost up the level of particular micronutrient in the crop. Currently, this technology is being focused to elevate the zinc, iron, and pro-vitamin A carotenoid levels in some of the World's most important staple food-crops, i.e. rice, wheat, and maize (Hambidge, & Huffer & et al., 2004).

In addition, food dietary diversification is considered as a preventive strategy to micronutrients deficiency. Dietary diversification like consumption of meat, poultry or fish, and all good sources of zinc recommended for minimize of zinc deficiency prevalence (Caulfield & Black, 2009). Selection of foods, modification in traditional methods of food preparation and focused food production are a few important considerations for adequate zinc supply through this approach (Hua & et. al., 2015).

3.9. General Assessment of Zinc Status

UNICEF, IZiNCG and WHO are recommended indicators to assess zinc status and epidemiological criteria have to consider zinc nutrition as a public health concern. If > 20% of the population has low serum zinc level and > 25% of the population has low dietary zinc intake and prevalence of stunting is > 20% in a given population, zinc nutrition is public health concern (Gibson, 2017; King, 2000; Blair, 2006; Friel & Andrews & et. al., 1993).

3.9.1. Biochemical Indicators

Since the use of zinc for human health was recognized, there has been tremendous effort to be carried out to identify and validate indices of zinc levels. However, there has been limited success. So far there is lack of single specific and sensitive biochemical index that shows the whole spectrum of zinc levels from low to excess. However, existed biochemical indicators include serum, erythrocyte, leukocyte, urinary and hair zinc concentrations. Serum zinc is the most frequently used biomarker. Several studies have confirmed its importance of assessing zinc status at community levels. Erythrocyte zinc is an alternative measurement to indicate zinc concentration status but it does not show short time variations in zinc status. Leukocyte zinc is more sensitive than erythrocyte zinc; however, its interpretive criterion is yet to be established. Urinary zinc is not a sensitive indicator as it only varies at extreme deficiency or high dose consumption states. Hair zinc concentration reflects chronic deficiency when protein energy malnutrition is absent. However, it is not helpful in determining short-term of zinc deficiency (Gibson, 2017).

3.9.2. Dietary Intake Method of Zinc Assessment

The assessment of zinc by using dietary intakes in the population is important because inadequate dietary intake of zinc is most likely lead to zinc deficiency.

There are quantitative ways to assessing usual dietary intakes of individuals: weighed food records, recalls, and semi-quantitative food frequency questioners. Of these, food weighed records and recalls are designed to measure the quantity of each food consumed over a one-day period. By contrast, food frequency questionnaire (FFQ) obtains retrospective information on the pattern of food consumption during a longer time period, and sometimes on the usual intakes of certain nutrients (Gibson, 2017; King, 2000; Blair, 2006).

Weighed food records are the most accurate and reliable methods of determining actual consumed at household levels during the recording period. However, this method is more time taking and costly and also may increase the lively hood of respondents change their dietary intakes during record period.

This may be leads to erroneous outcome. Dietary recalls were used to estimating zinc consumed among illiterate's peoples. It is suitable where diets are not very diverse and dominantly consumed plant food sources. Although some of its accuracy recalls method is compromised by their implementation, and it is easy, faster, and less cost than weighed food records (Gibson, 2017; King, 2000 & Blair, 2006).

3.9.3. Prevalence of stunting (clinical assessment)

Prevalence of zinc deficiency is correlation with clinical impacts and growth-retardation (e.g. vomiting, diarrhea, stunting). The response to zinc supplementation was significantly changed on anthropometric measure of children pre-exciting nutritional stunting and underweight. On the other hands, no significant impact of zinc supplementation of children were non-stunted .These out comes imply that children with low height-for-age or weight-for-age are likely having zinc deficiency. In addition to this it indicate the national prevalence of stunting or underweight for children less than 5 years. Indirect this indicate that the risk of zinc deficiency status of a population. The WHO takes into account if national stunting rates of ≥20% to be a level of public health problems (Blair, 2006; Friel & et. al., 1993; Akhtar, 2013).

4. Methodology

4.1. Study Area and Period

The Study was conducted from September to November, 2018 among pregnant women attending ANC, at selected health centers in Nifas Silk Lafto Sub-city, Addis Ababa.

4.2. Study Design

Institutional based cross-sectional study.

4.3. Source Population

All pregnant women attending ANC follow up at Nifas Silk Lafto Health Center.

4.4. Study population

Pregnant women visiting Nifas Silk Lafto Health Center for ANC follow up during the study period.

4.5. Inclusion Criteria

All pregnant women enrolled for ANC visit with 1st, 2nd and 3rd trimester except those critical ill during data collection.

4.6. Variables

Table 3:- Study variables

Independent variables	Dependent variable
Age, Marital status, Religion	Serum zinc
Educational status	
CRP, Hemoglobin level	
Dietary characteristics	
Anthropometric characteristics	
Trimester, Parity,	

4.7. Sample Size Determination and Technique

Sample size was determined by using single proportion population formula considering 95% CI, 39.5% (Regassa, 2017) probability of occurrence, a 5% margin of error and 10% increase for non-response.

$$n = \frac{(Z\alpha/2)^2\ p\ (1-p)}{(d)^2} = \frac{(1.96)^2\ 0.395\ (1-0.395)}{(0.05)^2} = 367.22 \sim \underline{367}$$

The source populations of the study area were 462 pregnant women on ANC follow up during study period. Since the total source of study population were less than 10,000, then sample size correction formula was made to get the actual sample size (N=462).

nf= n/(1+n/N)

Where, nf = Final Sample size

n = First calculated Sample size

N = Source of Study Population

nf =367/(1 +367/462)= 205

Adding a 10% (205) of non-response rate =20.5=21

Total sample size =21 + 205= 226 pregnant women were recruited from ANC. However, only about 212 of pregnant women was participated in this study with response rate of 93.8%.

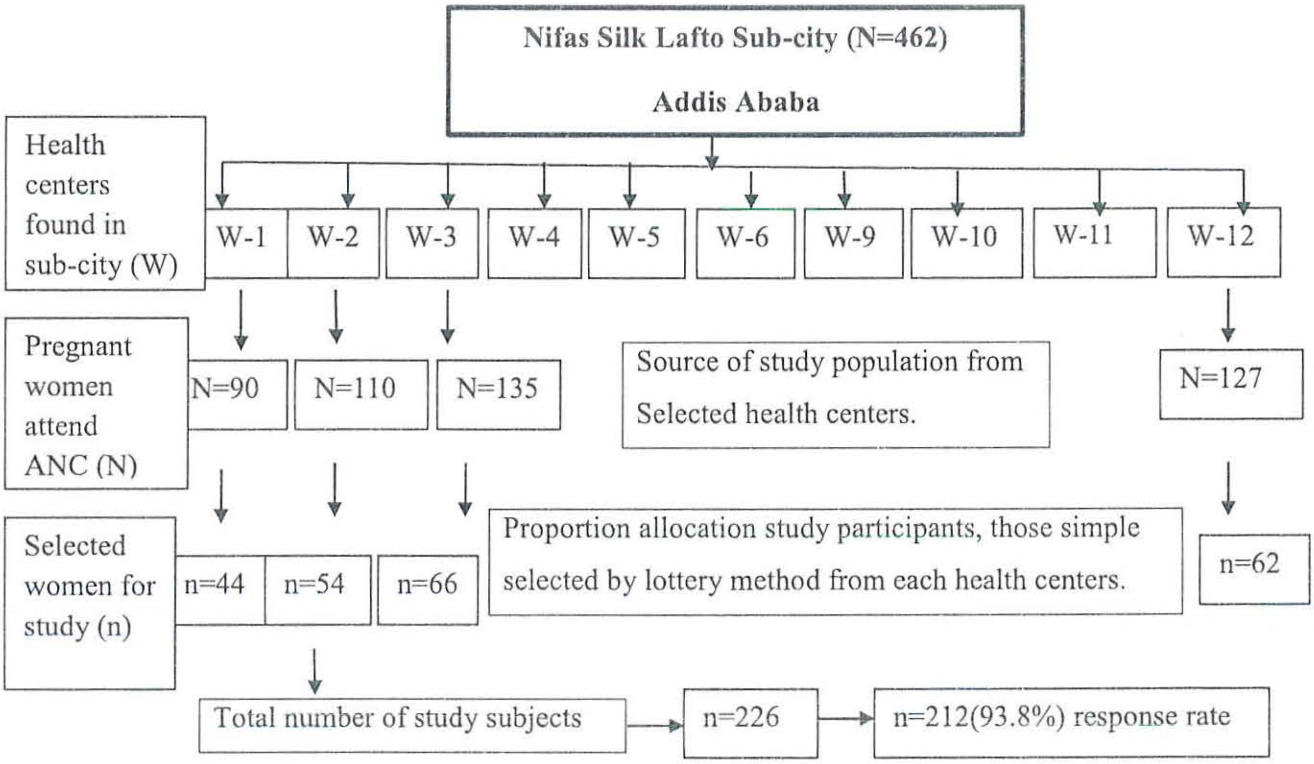

Figure 1:- Sample size determination procedure frame diagram.

4.8. Data Collection Method

Socio-demography

A structured and pretested questionnaire was used to collect information concerning socio-demographic characteristics and economic status of the present study participating women. The questionnaire was prepared in English and translated to Amharic and back translated to English for consistency. Laboratory technician and nurses administered the interview and blood collection after short training was given for one day.

Obstetrics maternal history of study subjects such as number of gravid, parity (null parity, one parity and multi parity), trimester, history of abortion, still birth and low birth weight.

Dietary characteristics

Dietary characteristics of participating women were collected using a 24 hour recall method which was adopted form Food and Agriculture organization (FAO, 2011). All foods and drinks that were consumed by the women were listed and the participants were asked if they consumed the food among the list 24hrs preceding the survey. An individual dietary diversity score (IDDS) and food variety score (FVS) of the participating women was derived based the 24 hour dietary recall data. A DDS value <3 was considered low and ≥ 5 is high. In addition, intake of iron folic acid tablets was inquired.

Table 4:- Individual Dietary diversity food groups of pregnant women (FAO. 2011).

1. Starch
2. Legumes
3. Vitamin "A" rich foods
4. Organ meat
5. Others Fruits and Vegetables
6. Milk and Milk products
7. Meat and fish
8. Egg
9. Dark green leafy vegetables

Anthropometry parameters

Weights, height, MUAC were measured & consequently BMI was calculated. Weight of the participating women was measured using regularly calibrate the weight balance (digital balance or balanced beam scale) (model 500; SR instruments, Tonawanda, NY). During measure the weight, individuals wearied light clothes and record & read to the nearest 100gm.

Height was measured using measuring board attached with a measuring tape (235 heightronic digital; Seca, Hamburg, Germany). The subjects stand erect and bare footed on a measuring board with a movable head piece. The head piece is leveled with the skull vault and the height is recorded and read nearest to 0.1 cm. Height and weight measurements result were used to assess nutritional status. After that, BMI of participating women was calculated. BMI was grouped as the following:- sever underweight (<16), underweight (16-18.5), normal (18.5-24.9), overweight (25-29.9), and obesity (> 30kg/m^2) for purpose of analysis.

A flexible and non-stretchable measuring tape was used determine MUAC. After determine the mid-point between the elbow and the shoulder place the tape measure on the mid arm of pregnant women, then read and record to the nearest 0.1cm or 1mm, which determine the nutritional status of the participants. And also it was categorized as <20.9 cm (undernourished), >21cm (healthy nutrition).

Blood Sample Collection and Preparation

Venous blood was drawn from the upper arm of mothers by an experienced laboratory technician and follows correct procedure and wears disposable gloves free of talc or other coatings to avoid zinc contamination. Tourniquet used for occlusion of the pregnant women arm was limited to <1min. Vacutainer (20 and 21 gauge) butterfly needles (Becton Dickinson, Franklin Lakes, NJ) and 7ml rolay yellow topped Vacutainer tubes (Becton Dickinson) certified as trace element free were used for blood collection. About 5ml of whole blood was collected from antecubital vein and pippeted into HemoCue microcuvettes (WHO /UNCEF/IAEA/IZiNCG, 2007).

After sample collection, the blood was allowed to clot for 20 minutes in a closed ice box and centrifuged at 3000revoultion per minute (RPM) for 10 minutes. Then serum was extracted and transferred into labeled screw-top Cryogenic vials. During this time few obviously hemolyzed samples were identified and discarded. The same day they were stored frozen at -20^{0}C. At the end of the survey the samples were transferred into ice box and transported to the Addis Ababa University, Center for Food Science and Nutrition laboratory and kept frozen at -80^{0}C until analysis.

Laboratory Analysis and Procedure Frame Diagram:-

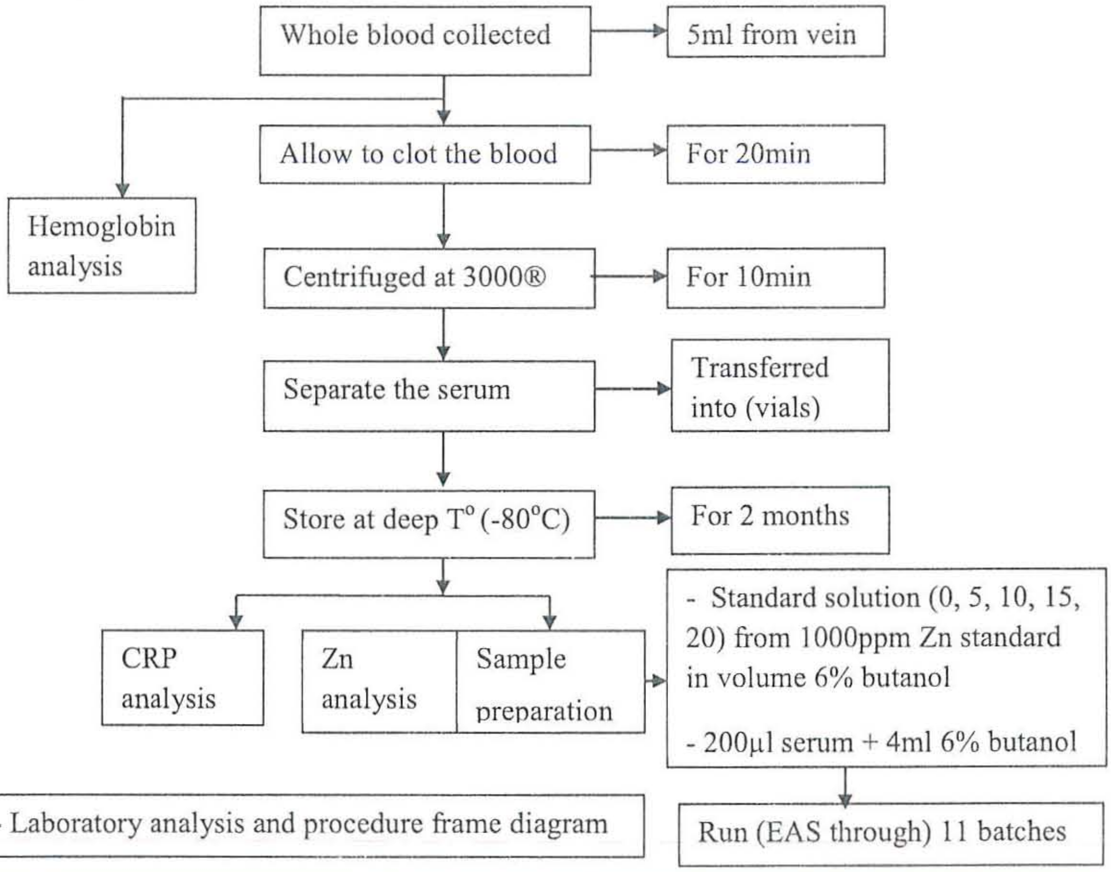

Figure 2:- Laboratory analysis and procedure frame diagram

Zinc concentration was determined using Atomic emission spectroscopy (MP-AES), agilent technologies 4200 at Addis Ababa University. Before standard solutions prepare all glass, bottles, pipettes and other materials were washed with diluted nitric acid (10%) and rinsed with de-ionized water. And also all instruments were dried in heat oven.

Initially; standards solution of 0, 5, 10, 15 and 20 ppm were prepared by diluting 1000ppm zinc standard in appropriate volume of 6% butanol. Then the standards were used for calibration. Samples were analyzed at a wave length of 213.9nm, with lamp current of 5mA and slit width of 1nm. After diluting 200μl serum sample with 4ml of 6% butanol in well vortexes and MP-AES optimized with control and blank sample, the zinc concentration of each sample was analyzed. The measurement is automatically carried out according to the standard calibration method and results are average of two replicates.

Samples were analyzed through 11 batches. A control sample with known concentration and multiple blank samples were analyzed with every batch. At times when unexpected concentration is reported either for the control or blank samples, sample preparation and analyses were repeated for the whole batch. The MP-AES system was flushed with 6% butanol after every analysis. Zinc deficiency was defined as a serum zinc level <56 μg/dl during the first trimester, or < 50μg/dl during the second or third trimester.

C-reactive Protein Analysis:- Serum CRP was assessed by using a Nyco Card reader II (Polymedco Inc, Cortlandt Manor NY) (WHO /UNCEF/IAEA/IZiNCG, 2007). And the analyses were conducted at Dr Worku medium clinic.

Hemoglobin Analysis:- Hemoglobin concentrations were measured within 5min of blood collection with the use of the HemoCue B- Hemoglobin machine (Angelholm, Sweden) (WHO /UNCEF /IAEA/IZiNCG., 2007). Analysis was conducted at health facility of study area. Anemia was defined as a hemoglobin level of (at sea level) < 11.0 g/dl during the 1st or 3rd trimester and < 10.5 g/dl during the 2nd trimester. According to the formula recommended by Center for Disease Prevention and Control (CDC), hemoglobin values were adjusted for altitude.

4.9. Data Quality Assurances

Prior to the actual data collection, the questionnaire was per-tested in 5% of the estimated number of participants. Blank samples and calibration solutions of known concentration were also prepared during serum zinc analysis.

4.10. Data Processing and Analysis

The raw data was entered into epi-data version 3.1 and exported to SPSS version 21.0.for analysis. Descriptions of mean, median, standard deviation were computed for quantative variables and simple frequencies and percentage of the given data were calculated for each variable. Correlation and logistic regression analysis were used to determine the association between independent and outcome variables. Bi-variable logistic analysis was done at the first step (Taking each independent variable with the dependent variable at a time). Then the variables which were significant at 0.2 p-values were taken in the multivariable logistic regression. A value of $P < 0.05$ was taken as significant of association with 95% CI. The finally results were displayed by text, figure and table.

4.11. Ethical Consideration

An ethical approval was obtained from Institutional Review Board of Addis Ababa University at College of Natural and Computational Sciences. A support letter was also obtained from Addis Ababa City administration Health Bureau. The benefit and risk of the study was explained to participating women and oral consent was obtained.

5. Result

5.1. Socio-demographic characteristics of Study Participants

The study women were in the age range of 15-42 years with mean age of 25.1 $\pm$ 4.0 years. Majority (68.9%) of the participants were unemployed. A third of (29.2%) pregnant women were illiterate. The majority (70.8%) households spent < 2000.00 birr for food per month. About 32.1% of study women were earning 2001-4000 birr monthly incomes. Only 4.7% of pregnant women were unmarried.

Table 5:- Frequency distribution of socio-demographic characteristics of study subjects at selected health centers in Addis Ababa, 2019.

Variables	n (%)
Age	
$\leq$ 20	35(16.5)
21-34	155(73.1)
$\geq$ 35	22(10.4)
Religion	
Orthodox	127(59.9)
Muslim	54(25.5)
Protestant	31(14.6)
Married	202(95.3)
Ethnicity	
Amhara	85(40.1)
Oromo	57(26.9)
Gurage	36(17.0)
Others (Siltie, Tigre, Sidamo, Walata….)	34(16.0)
Education level	
Illiterate (unable to read or write)	62(29.2)
Primary	22(10.4)
Secondary	35(16.5)
Diploma	52(24.5)
Others(Degree, Master, PhD, Certificate)	41(17.4)
Monthly income ;- $\leq$2000.00 birr	62(29.2)
$\geq$4001.00birr	82(38.7)

5.2. Obstetrics' Information of Pregnant Women

In the present study, 44.8% of pregnant women came to ANC follow up at 2nd trimester. The rest about 37.3% and 17.9% of participating women come to ANC visit at 1st and 3rd trimesters respectively. Nearly three fifth of participants (62.7%) were multi-gravid mothers. Slightly more than half (52.8%) of pregnant women had history of more than two number of births. Few numbers of mothers had history of still birth (2.8%) and low birth weight (5.2%). See table 6

Table 6:- Distribution of obstetrics' information among study subjects at selected health centers, Addis Ababa, 2019.

Variables	n (%)
Gravid numbers	
Prim-gravid	79(37.3)
Multi-gravid	133(62.7)
Trimester	
First trimester	79(37.3)
Second trimester	95(44.8)
Third trimester	38(17.9)
Numbers of parity	
Null parity	79(37.3)
One parity	21(9.9)
Multi parity	112(52.8)
History of abortion	63(29.7)
Number of Abortion	
One	41(65.1)
Two	22(34.9)
Types of Abortion	
Spontaneous	56(88.9
Induced	7(11.1)
History of still birth	6(2.8)
History of delivering low birth weight child	11(5.2)

5.3. Clinical Health Condition of Pregnant Women

Nearly about one fourth (23.1%) of pregnant women had elevated CRP concentration (>5mg/dl). Nearly a quarter (26.9%) of the present women had sickness two weeks prior the survey. In addition, 7.5% of women had history of smoking (Table 7).

Table 7:- Clinical related information of study subjects at selected health centers, Addis Ababa, 2019.

Variables	n (%)
C-reactive protein	
>5mg/dl (reactive)	49(23.1)
Morbidity during pregnancy	57(26.9)
History of smoking	16(7.5)
Duration of blood sample collection	
Morning	164(77.4)
Afternoon	48(22.6)

5.4. Hemoglobin level of Pregnant Women

In this study, 22.2% of women were taking iron folic acid tablet during data collection. The range hemoglobin level of pregnant women was 9.2-17.5g/dl with mean of 12.8$\pm$1.2g/dl. About 21(9.9%) of pregnant women had low hemoglobin level. One in ten of pregnant women were anemic.

Pregnant women who didn't take iron folic acid tablets were more anemic (10.9% vs 6.45, p=0.035) than their counters. Second trimester women was more (8.9% vs 12.6%, p=0.045) anemic than first trimesters. Pregnant women who had >2 history of abortion had less hemoglobin levels (13.6% vs 7.3%, p=0.015) than their counters. Undernourished (MUAC <20.9 cm) pregnant women had low hemoglobin level (14%, vs 5.7%, p= 0.043) than normal or well-nourished one.

Pregnant women who have low dietary diversity score was more anemic than those who have high dietary diversity score (12.2% vs 6.2%, p=0.015) 24hrs preceding survey. High prevalence of anemia was observed among coffee drink participants than not drink a coffee after meal (12.5% vs 1.9%, p=0.027). Animal source foods consumed women have better hemoglobin level than not consumed (9.6% vs 10.3%, p= 0.058).

Table 8:- Prevalence of hemoglobin level among pregnant women at selected health centers.

Variables	Hemoglobin status of women <11g/dl n(%)	>11.1g/dl n(%)	p-values
Trimesters			
1st	7(8.9)	72(91.1)	
2nd	12(12.6)	83(87.4)	
3rd	2(5.3)	36(94.7)	0. 045
BMI			
Sever undernourished	1(50)	1(50)	
Under weight	1(4.5)	21(95.5)	
Normal	14(9)	141(91)	
Over weight	5(17.9)	23(82.1)	0.037
MUAC			
≤20.9cm	6(5.7)	99(94.3)	
≥21cm	15(14)	92(86)	0.043

5.5. Nutritional status of women

The range of BMI was 15.80 - 35.2 kg/m^2 with mean of 21.8±3kg/m^2. Nearly three fourth (73.1%) of pregnant women had normal BMI. One in ten of study participants (10.3%) were underweight (BMI< 18.5). On the other hand, 15.6% of pregnant women were overweight (Table 9).

Table 9:- Nutritional status of study subjects at selected health centers, Addis Ababa, 2019.

Variables	n (%)
BMI	
Sever under nutrition	2(0.9)
Under weight	22(10.4)
Normal	155(73.1)
Over weight	33(15.6)
MUAC	
≤ 20.9cm	35(16.5)
≥21cm	177(83.5)

Abbreviations: MUAC: Mid Upper Arm Circumference, BMI: Body Mass Index

5.6. Dietary characteristics

The most dominant food variety items frequently intake by pregnant women were Teff (93.4%), Pea (76.9%) and Leave vegetable (52.4%) respectively while sorghum and millet were not consumed.

Table 10:- Distribution food variety of study participants at selected health centers, Addis Ababa.

Food items	n (%)
Teff	198(93.4)
Maize	43(20.3)
Wheat	28(13.2)
Rice	64(30.2)
Potatoes	90(42.5)
Sugar	133(62.7)
Bean	25(11.8)
Pea	163(76.9)
Carrot	64(30.2)
Leafy vegetables	111(52.4)
Papaya	15(7.1)
Mango	19(9)
Cow meat	36(17)
Berbere	165(77.8)
Tomatoes	52(24.5)
Orange	45(21.2)
Banana	62(29.2)
Avocado	16(7.5)
Others (lemon, chicken, sheep, ground nut, onion, sweet potatoes & honey)	24(11.5)

Majority of the participants (95.8%) ate starchy staples 24 hours preceding the interview followed by other fruits and vegetables (81.6%), legumes (76.9%) and Vitamin "A" rich foods (71.7%). See table11. On other hand, about 87(41.0%) of pregnant women were not intake animal source foods during 24hrs preceding survey. Slightly more than half 115(54.2%) of study subjects are coffee drink immediately after meal. And also about 4(1.9%) of participant women had history of alcohol drink. About 30(14.2%) of participants were beverages (soft drink) during meal intake.

Table 11:- Dietary diversity of pregnant women at selected health centers, Addis Ababa, 2019.

Variables	n (%)
Starch[1]	203(95.8)
Legumes[2]	163 (76.9)
Vitamin "A" rich foods[3]	152 (71.7)
Organ meat	5 (2.5)
Other fruits and vegetables[4]	173 (81.6)
Milk and Milk products[5]	79 (37.3)
Meat and fish [6]	46 (21.7)
Dark green vegetables[7]	111(52.4)
Eggs	45 (21.2)

[1]Cereals, sweets, white roots and tubers

[2]Dried beans, dried peas, ground nuts and seeds

[3]Vitamin A rich vegetables and fruits like carrot, orange, ripe mango and papaya

[4]Tomatoes, leafy vegetables, lemon, banana and avocado

[5]Cheese, yogurt and other milk products

[6]Flesh meats and fish

[7]Kales, spinach, kunde (cow pea leaves), French beans and other African leafy

Dietary diversity score of study subjects

Participants had a dietary diversity score in the range of 2-7 with mean of 4.9 $\pm$1.1. Almost half of the study subjects (52.8%) had medium dietary diversity score which consuming 4 or 5 food groups and 38.2 % had high dietary diversity score consuming more than 5 food groups. See figure 3.

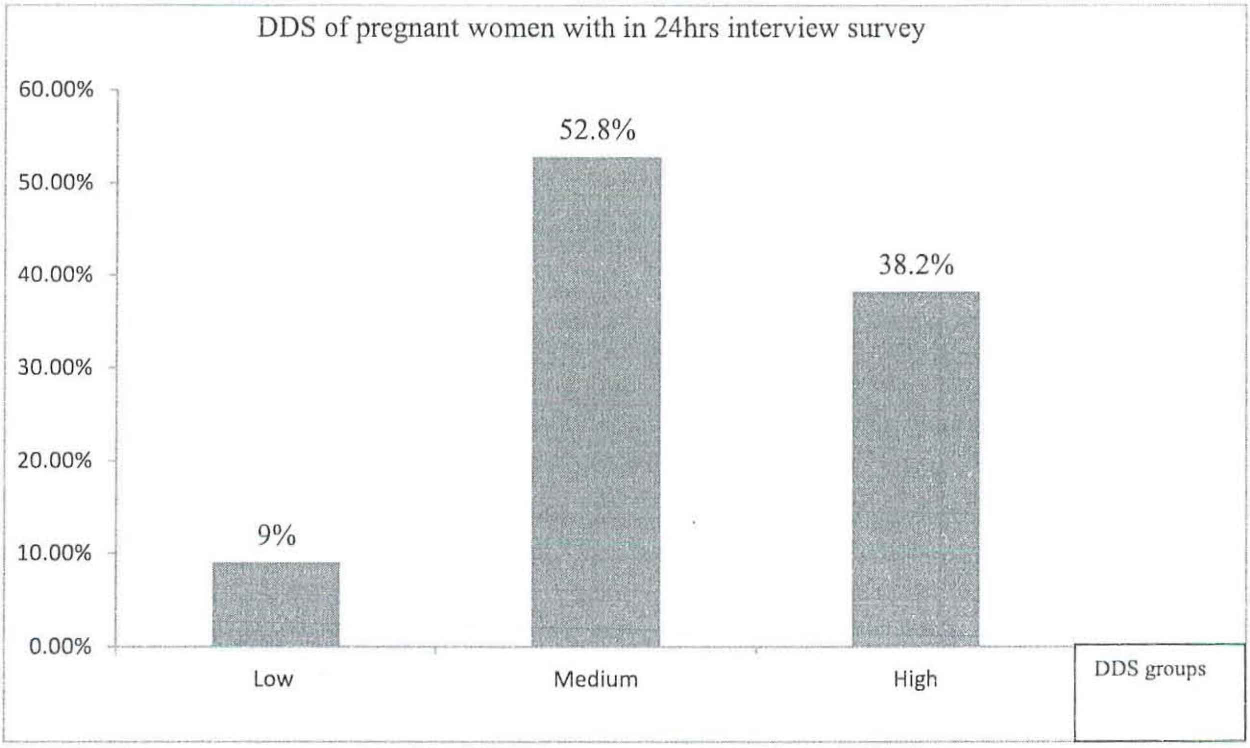

Figure 3:- Dieter Diversity score of pregnant women at selected health centers, Addis Ababa

5.7. Prevalence of Zinc Deficiency

Serum zinc concentration was in the range of 5.0 - 274.8µg/dl with median value of 90.5µg/dl. Zinc deficiency was observed in 32.1% pregnant women. The prevalence of zinc deficiency among first, second and third trimester pregnant women were 21.1%, 25.3 % and 45.5% ($p=0.005$) respectively.

High prevalence of zinc deficiency was observed in multigravida and multiparty women than prim-gravida (37.6% vs 22.8%, $p=0.026$) & null parity women (41.1 vs 22 %, $p=0.003$) respectively. Participating women from households earning monthly income of less than 2000 birr and spend less birr for food had higher zinc deficiency prevalence (58.1% vs 43.0% , $p=<0.001$) and 34.0% vs 18.7%, $p=0.020$) respectively.

Anemic pregnant women had higher prevalence of zinc deficiency than non-anemic mothers (38.1 vs 31.4%; $p=0.034$). Illiterate women had higher prevalence of zinc deficiency when compared with primary educated women (30.6% vs 27.3%, $p=0.051$). Low prevalence of zinc deficiency was observed among animal source intake women than not intake animal source food staffs (23.2% vs 44.8%, $p=0.001$). Coffee drink immediately after meal pregnant women had more prevalence of zinc deficiency than their counters (42.6% vs 19.6%, $p< 0.001$).

5.8. Associated Factors with Serum Zinc Concentration

5.8.1. Correlates of Zinc deficiency

The serum zinc level of pregnant women was positively correlated with (r= 0.235, p=0.001) monthly income of the households.

In this study, MUAC measurement of pregnant women was weakly but positive correlated (r=0.147, p=0.022) with serum zinc levels. The median serum zinc concentrations of MUAC measurement of undernourished and well-nourished of the study participants were 89.7 and 92.1cm respectively. Well-nourished pregnant women had high media MUAC measurement than undernourished (p=0.022). The median serum zinc concentrations of underweight, normal and overweight of study subjects were 58.2, 92.1 and 97.5kg/m2 respectively. Overweight pregnant women had more median BMI than their counters (p=0.223).

Participants with low, medium and high DDS had median serum zinc concentration were 38.1, 79.4 and 107μg/dl respectively. Study subjects with low DDS had significantly low median serum zinc concentration compared to medium and high DDS groups (p=0.003) (Figure 4).

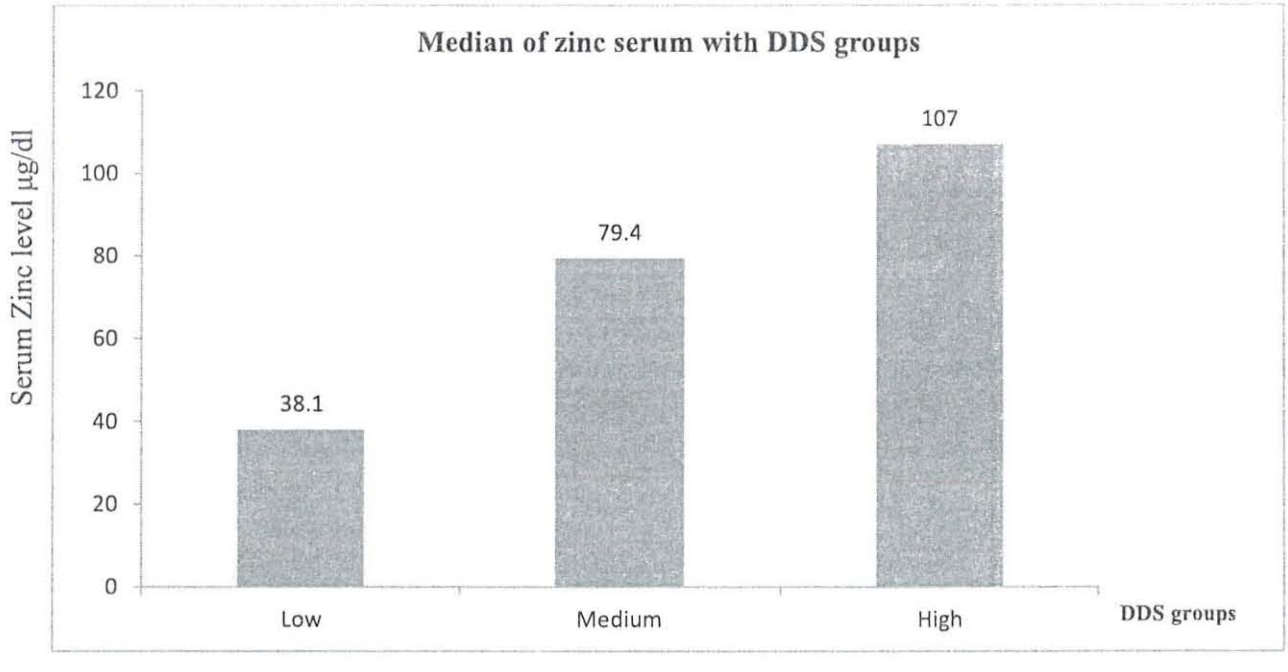

Figure 4:- Distribution of median serum zinc level with DDS of participants

5.8. 2. Associated Factors with Serum Zinc Concentration

Age of respondents, monthly incomes, monthly cost for food, C-reactive protein level, morbidity during pregnancy, history of smoking, trimester, gravid numbers, parity, BMI, MUAC, history of still birth, history of low birth weight delivery, milk and milk products intake, DDS, intake of animal source foods, and coffee drink after meal were analyzed by bi-variate logistic regression model for predictors of zinc deficiency.

Monthly incomes, C-reactive protein level, trimester, parity, history of low birth weight delivery, milk and milk products intake, DDS, and intake of animal source foods were entered together into multi logistic regression model and significantly associated with serum zinc level (p=0.2).

Monthly income:- Pregnant women monthly income < 2000 birr is about 8 times odd of zinc deficiency than pregnant women whose monthly income > 4001 birr (AOR: 7.773, P : <0.001). The likelihood of zinc deficiency among pregnant women monthly income < 2000 birr is about 4 times when compared to pregnant women who monthly income is 2001- 4000 birr (AOR: 3.718, P : 0.019)

Gestation period: Second trimesters of pregnant women have three times odd of zinc deficiency during pregnancy when compared with first trimester one (AOR: 3.325, P: 0.019). The likelihood of zinc deficiency among pregnant women who have third trimester of pregnant is about 2.6 times greater than first trimester women (AOR: 2.662, P: 0.160).

Have history of Low birth Weight: The likelihood of zinc deficiency among pregnant women who have no history of low birth weight in past time is reduced by about more than 95% when compared to pregnant women who have history of low birth weight in previous time (AOR: 0.030, P: <0.001).

Dietary Diversity Score: The likelihood of zinc deficiency among pregnant women who have higher dietary diversity score is lower by about > 92% when compared to pregnant women who have low dietary diversity score (AOR: 0.075, P: <0.001). And also the likelihood of zinc deficiency among pregnant women who have medium dietary diversity score is lower by about 40% when compared with pregnant women who have lower dietary diversity score (AOR: 0.604, P: 0.361).

Milk and Milk products: Pregnant women who not intake milk and milk products have about >15 times odd of zinc deficiency as compared to consumed one (AOR: 16.515, P: <0.001).

Animal source foods intake: Pregnant women who intake animal source food staffs was reduced about 80% risk of zinc deficiency than pregnant women who not intake it (AOR: 0.195, P: 0.094).

Table 12:- Associated factors with serum zinc level among pregnant women at selected health centers, Addis Ababa.

Variables	COR (CI, 95%)	AOR (CI, 95%)	P-value
Monthly incomes			
≤ 2000 birr	5.712(2.716-12.013)	7.773(2.493-24.240)	< 0.001
2001- 4000birr	4.500(2.117-9.564)	3.718(1.239-11.156)	0.019
≥4001birr	1	1	
CRP			
Reactive	1	1	
Non-reactive	0.055(0.025-0.124)	0.051(0.017-0.152)	< 0.001
Gestational age			
1st Trimester	1	1	
2nd Trimester	2.477(1.305-4.699)	3.325 (1.222-9.046)	0.019
3rd Trimester	3.140(1.281-7.697)	2.662 (0.678-10.447)	0.160
Parity			
Multi Parous	1	1	
Null Parous	0.405(0.221-0.741)	0.320 (0.125-0.820)	0.018
Have history of LWB delivery			
Yes	1	1	
No	0.160(0.041-0.622)	0.030 (0.003-0.261)	<0.001
Intake of milk & milk products			
Yes	1	1	
No	4.113(1.824-9.272)	16.515(3.431-79.495)	<0.001
Dietary diversity			
Low	1	1	
Medium	0.719(0.373-1.386)	0.075 (0.017-0.327)	<0.001
High	0.155(0.061-0.397)	0.604 (0.205-1.779)	0.361
Animal source foods intake			
No	1	1	
Yes	0.236(0.097-0.571)	0.195 (0.029-1.319)	0.094

Abbreviations: COR: Crude Odds Ratio, AOR; Adjusted Odds Ratio, CI: Confidence Interval, LWB: Low Birth Weight, CRP: C - reactive protein

6. Discussion

Zinc deficiency is the most widespread problem and a common contributor to poor growth, intellectual impairment, prenatal complications and increased risk of morbidity and mortality. The cycle of zinc deficiency continue from generation to generation with far consequence on the future population. Pregnant mothers and children under five age groups are the main risk groups of population for zinc deficiencies. Several factors contribute to low zinc status including inadequate dietary intake, physiological requirements and limited absorption. Therefore institutional based cross- sectional study was conducted to assess serum zinc level and associated factors among pregnant women. About 32.1% pregnant women had low serum zinc level. Serum zinc level was significantly associated with monthly income, C-reactive protein level, and trimester, number of parity, dietary diversity score and animal source food stuffs.

Zinc is important for normal growth and development of the fetus. However, zinc deficiency is highly prevalent in pregnant women from resource poor settings. In Ethiopia, 53 to 76% of pregnant women are zinc deficient (Kumera & et. al., 2015). Another study in Sidama reported prevalence of zinc deficiency was 76% (Gebremedhin, Enquselassie & Umeta, 2011). On the other hand study conducted in Addis Ababa reported that less (39.5%) number of pregnant women had zinc deficiency than the previous study (Regassa, 2017). This finding number is more in line with the current study result (32.1%). Most of the studies conducted at rural than urban. However, the differences may be due to urban area mothers have more socially and economical advantageous to get zinc rich diets, get better access of health service and have better knowledge toward causes of zinc deficiency (Gebremedhin, Enquselassie & Umeta, 2011; Yadrick, Kenney, & Winterfeldt, 1989). In addition, urban inhabitants have access to information that can positively influence their dietary, sanitation and hygiene habit and then serum zinc concentration (Kumera, & et. al., 2015). Moreover, the higher prevalence of zinc deficiency in the previous studies might also be due to seasonal differences and time gap (CAULFiELD, & Black, 2004).

Studies show that maternal zinc deficiency during pregnancy is associated to adverse effects such as intrauterine growth retardation (Simmer and Thomson, 1985). In addition, low maternal zinc was associated to delivery of low birth weight infants (Osrin, de L Costello, 2000). A study by, Neggers et al.(1990) shows that pregnant women with serum zinc at the lowest quartile gave birth to significantly low birth weight infants. And also in current study finding reported that pregnant women who had no LBW delivery history reduced by > 95% chance of zinc deficient. This shows that low serum zinc concentration was associated with low birth weight and also came from previous pregnancies up to current pregnancy. On the other hand, studies are available with conflicting results which failed to show significant relationship between zinc status during pregnancy and low birth weight (Shah and Sachder, 2006). However, in low income countries the main causes of LBW is due to poor nutrition during pregnancy period (Klein, 2002).

A higher and medium socio-economic status enhances maternal zinc status (Ugwuja & et. al., 2010). In addition, Kenya National Bureau of Statistics (2010) reported that majority of the pregnant women (75%) were low socio-economic class. However, in the above study report, household wealth index was not significantly associated to zinc status. Our study find is against the above studies result. Pregnant women monthly income <2000 birr is eight times odd of low serum zinc concentration than monthly income >4001birr. Hence, maternal zinc deficiency during pregnancy is significantly associated with monthly income of the families.

A lot of maternal physiological changes occurred during pregnancy. This condition required high zinc demand through pregnancy period (DiSilvestro, 2004). As gestational age increase the serum zinc concentration was be decline (Gebremedhin, Enquselassie, Umeta, 2011). The declining of serum zinc level had potential effect on biological values of pregnant women including protein synthesis, cellular division and nucleic acid metabolism and high impact on pregnancy outcomes (King, 2000). The current study result shown that pregnant women with second trimesters have three times risk of zinc deficiency when compared with first trimester pregnant. This shown that, as gestation age increasing the chance of exposed to zinc deficient is also increasing. On the other hand, the biological expectation on parity is that serum zinc levels decreases with an increase with parity (IZiNCG, 2009). The different study finding witnessed an association between parity and zinc status. This study result reported that repeated pregnancies deplete maternal zinc stores. Other previous studies conducted in Ethiopia, Nigeria and USA also gave similar findings (Gebremedhin, Enquselassie, and Umeta, 2011; Ugwuja & et. al., 2010; Neggers, et. al, 1996). And also our study find reveals that the numbers of parity was positively associated with zinc deficiency. This result supported by other studies (Gebremedhin, Enquselassie, Umeta, 2011; Kumera, & Awoke, 2015). However, study in Kenya reveals that the prevalence of zinc deficiency during pregnancy is negatively associated with number of parity (NDUTAH, 2013).

Zinc deficiency is impairs overall immune function and resistance to infection. Zinc has clearly an important role in infant and childhood infectious diseases. An acute inflammation or infection is independently affect maternal serum zinc levels as redistribution of zinc from the plasma into the tissues which affect and decline level of zinc concentrations in the serum (Gebremedhin, Enquselassie, Umeta, 2011). In addition, serum zinc level was significant associated with elevated CRP level (Regassa, 2017; Abebe, Bogale, Hambidge, Stoecker, Arbide, Teshome, et al., 2007). Similarly the current study reveals that normal CRP status of pregnant women have reduced chance of zinc deficiency when compared to elevated CRP women. This indicated that due to inflammatory processes the serum zinc level decline.

Zinc deficiency and anemia tend to occur together. About 12.6% of the subjects had both anemia and zinc deficiency and about half, 48.8% of anemic pregnant women had zinc deficiency (Regassa, 2017). Similarly previous studies also found positive significant association between zinc deficiency and lower hemoglobin level (Kumera, & Awoke, et. al., 2015; Gebremedhin, Enquselassie, Umeta, 2011). This is due to zinc is known to take part in multiple metabolic path ways thus the deficiency might have casual role in anemia. This relation between zinc deficiency and anemia might be due to the role of zinc participate in the production of hemoglobin. Therefore, low concentration of zinc likely related to low production of hemoglobin this lead to anemia (Gibson, 2012). Our study also reported that high prevalence of anemia occurs among low serum zinc level women.

To consume high DD and phytate level of foods with low zinc concentration has less bioavailability for zinc absorption. This condition can result low serum zinc concentration. Study conducted in Pakistan (2011) shown that maternal serum zinc decline was related with mainly intake of starch dietary staple foods (Roohani, Hurrell, Kelishadi, & Schulin, 2013; Akhtar, 2013). This type of foods group contains high level of phytates and fiber that inhibit and limits zinc absorption (Gibson, 2017; Uriu-Adams, Keen, 2010). However, cereals and legumes to contribute relative high amount of zinc but also contribute important amount of phytate which highly reduce zinc bioavailability (Kim, Pai, Han, 2011). In addition, starchy roots and tubers also other kind of starch foods that have low zinc content was frequently intake by pregnant women (Uriu-Adams, Keen, 2010). Similarly, calcium and polyphenols are also inhibitors of bioavailability of zinc levels (Kim, Pai, Han, 2011). The starch staples and legumes contain foods were most abundant dieter diversity food groups frequently eaten by our study participants. But not significantly associated with serum zinc level. This might be due was fermentations process that limit phytate levels.

Different finding results describe that coffee drink immediately after meal is responsible to affect serum zinc concentration (Gebremedhin, Enquselassie, Umeta, 2011; Regassa, 2017). Coffee intake during pregnancy was negatively associated with zinc status. Women who drink coffee immediately after meal had two times higher odd of zinc deficiency compared to their counters (Regassa, 2017). More of current study participants were coffee drink immediately after meal. And also, high prevalence zinc deficiency are occurs among coffee drink pregnant women. This can be due to the effect of tannin within coffee, which inhibit zinc absorption from the lumen after meal.

Animal source diets are good source for bioavailability of zinc concentration. This is due to the presence of sulfur-containing amino acid (cysteine and methionine) that improve zinc absorption and have no phytic acid compound that inhibit zinc absorption in animal origin food sources (Gibson, 2017). Study conducted in Nigeria (2010) indicated that about 45.8% of pregnant women had low serum zinc level, which significantly related with low consumption of meat and dairy product. In addition, previous studies conducted in Ethiopia also reported the same finding (Gebremedhin, Enquselassie, Umeta, 2011; Regassa, 2017; Kumera, & Awoke, et. al., 2015). This study also shows that a serum zinc level of pregnant woman is related with animal source foods consumption. Pregnant women who have not intake milk and milk products are about more than 15 times higher odd zinc deficiency than women to consume milk and milk products frequently.

Insufficient dietary diversity intake is one of the main contributing factors to high prevalence of zinc deficiency. Most of the dietary diversity consumed is plants diets (cereals and legumes) which have low zinc bioavailability, as compared to animal diets. Dietary diversity intake has remained a useful indicator in assessment of zinc deficiency among populations (IZiNCG, 2009). And also positive association was expected between dietary diversity intake and serum zinc levels. Findings from different studies reported that low serum zinc status is associated low dietary diversity intake (IZiNGC, 2009; Abebe et.al, 2007). However, the other study finding has controversial idea toward association between dietary diversity and serum zinc levels. Our study result shown that pregnant women with high DDS have less odd of zinc deficiency when compared to low DDS. In addition, other studies reported similar results with the current study finding (Gebremedhin, Enquselassie, Umeta, 2011; Kumera, & Awoke, et. al., 2015). Even though, study conducted in Addis Ababa were against the other studies results (Regassa, 2017). Pregnant women with low DDS had high serum zinc level than high DDS. The difference might be due to participants was consumed high DD with low zinc concentration or less bioavailability or to consumed low DD with high zinc concentration or easily bioavailable for zinc serum levels. In addition, absorption of zinc occurs inside lumen which depends on amount of food content and zinc concentrations or composition. An aqueous solutions form of zinc concentration is more fast absorption than solid form (Sandström, 1997).

7. Limitation of the Study

- Since the study was facility based, the participants may not represent the general population.
- 24hrs dietary diversity recall is not representing the frequently eaten habit of study subject.
- Phytate zinc ratio molar is not addressed.

8. Conclusions and Recommendations

8.1. Conclusions

The consequence of zinc deficiency during pregnancy to result maternal related complications and poor pregnancy outcomes. Therefore, the present study main focus on to assess the prevalence of zinc deficiency and to describe socio-demography, clinical feature of mothers, obstetric related information, nutritional status, dieter diversity and associated factors that influence serum zinc concentration among pregnant women from Addis Ababa.

This study reveals that the prevalence of zinc deficiency among pregnant women was remaining high. The distribution of zinc deficiencies is more observed among 21-30yrs age groups. High prevalence of low serum zinc level is associated with multigravida and multiparty women. Second trimester of pregnant women was significantly associated with serum zinc concentration. One in ten of pregnant women were anemic. Injera was the most domestic intake food stuff by study subjects. Most of the pregnancy women were frequently intake medium dieter diversity score. Serum zinc level was significantly associated with monthly income of families, C-reactive protein level, trimester, number of parity and dieter diversity foods.

8.2. Recommendations

To improve low serum zinc level, better to use different approach intervention strategies. And also better to consider zinc supplementation tablet for pregnant women.

Animal source food groups have high zinc concentration and significantly associated with serum zinc level, then to encourage them as to consume more animal source food stuffs during pregnancy. Furthermore, limit to eat low zinc concentration, high phytate and fiber food groups.

Dietary diversity intake during pregnancy is positive relation with serum zinc level: better to counsel the pregnant women on dietary diversity and food variety intake at household level which reduce maternal zinc deficiency during pregnancy.

Early detection and intervention of any inflammatory process during pregnancy have significant improve serum zinc level. Local accessibility of food items is also primary prevention way of zinc deficiency.

On fact, many low income countries women have no own source of income independently, which depend on others. Low monthly incomes of the pregnant women significantly influence serum zinc levels. Independently women's capacity build and creation opportunity of work is rise up family's income which significantly improve women dietary diversity score. Finally, it is better to emphasis toward maintains food security at house hold level to address micronutrient imbalance.

References

Abebe Y., Bogale A., Hambidge KM., Stoecker BJ., Arbide I., Teshome A., et al. (2007). Inadequate in takes of dietary zinc among pregnant women from subsistence households in Sidama, Southern Ethiopia. Public Health Nutr, 11,379–386.

Akhtar, S., (2013). Zinc status in South Asian populations—an update. Journal of health, population, and nutrition, 31, 139.

Allen L, de Benoist B, Dary O, Hurrell R, (2006.). Guideline for food fortification and micronutrients. Geneva: World Health Organization, 341.

Australian Government National Health and Medical Research council (2014). Nutrient reference values, Australia and New Zealand; 09-04.

Berni Canani R., Buccigrossi V., Passariello, A. (2011). Mechanisms of action of zinc in acute diarrhea. CurrOpin Gastroenterol, 27:8-12.

Black RE., Allen LH., Bhutta ZA., Caulfield LE., de Onis M., Ezzati M., et al. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. Lancet.;371:243–260.

Blair C. 2006). How similar is fluid cognition and general intelligence? Developmental neuroscience perspective on fluid cognition an aspect of human cognitive ability. Behav Brain Sci 29, 109-25.

Brown KH., & Hess SY. (2009). International Zinc Nutrition Consultative Group Technical Document No 2. Systematic reviews of zinc intervention strategies. Food Nutr Bull,; 30(1).

Caulfield DE., Black RE. (2009). Zinc deficiency: Available from: http://www.who. int/publications /cra/chapter/volume 1, October, 28. (2009)

Danesh A, Janghorbani M, Mohammadi B. (2010). Effects of zinc supplementation during pregnancy on pregnancy outcome in women with history of preterm delivery: a double-blind randomized, placebo-controlled trial. J Matern Fetal Neonatal Med.;23:403–408.

DiSilvestro, R. A. (2004). Hand-book of minerals as nutritional supplements. cRc press.

Engle-Stone, R., Ndjebayi, A. O., Nankap, M., Killilea, D. W., & Brown, K. H. (2014). Stunting prevalence, plasma zinc concentrations, and dietary zinc intakes in a nationally representative sample suggest a high risk of zinc deficiency among women and young children in Cameroon. The Journal of nutrition, 144, 382-391.

Ennes Dourado Ferro F., et. al., (2011). Biomarkers of metabolic syndrome and its relationship with the zinc nutritional status in obesity women. Nutr Hosp,;26: 650-654.

FAO. (2011).Guidelines for measuring household and individual dietay diversity; Food and Agriculture Organization of the United Nations; Rome, Italy.

Friel JK., Andrews WL., Mathew DJ., Long DR., Cornel AM., McKim MCD., Zerbe GO. (1993). Zinc supplementation in very low birth weight infants. J Ped Gastro Nutr; 1: 97–104.

Frost P., Sullivan J. (2008). Is zinc deficiency an important public health problem?: A review. 2008. [cited2009 October 21]; Available.

Gebremedhin S., Enquselassie F., Umeta M. (2011). Prevalence of prenatal zinc deficiency and its association with socio-demographic, dietary and health care related factors in rural Sidama, Southern Ethiopia: a cross-sectional study. BMC Public Health,;11: 898-908.

Getahun, Z., Urga, K., Ganebo, T., & Nigatu, A. (2017). Review of the status of malnutrition and trends in Ethiopia. The Ethiopian Journal of Health Development (EJHD).

Gibson, R. S. (2017). Global Importance of Zinc Deficiency In Humans: Its Relation to Malnutrition And Strategies for its Prevention. Retrieved May.10,

Gibson, R. S. (2012). Zinc deficiency and human health: etiology, health consequences, and future solutions. Plant and soil, 361, 291-299.

Hagmeyer, S., Haderspecrk, J.C., and Gabrucker, A. M. (2014). Behavioral impairments in animal models for zinc deficiency. Frontiers in behavioral neuroscience.

Hambidge KM., Huffer JW., Raboy V., Grunwald GK.,Westcott JL., Sian L., et al. (2004). Zinc absorption from low phytate hybrids of maize and wild-type isohybrids. Am J ClinNutr;79: 1053-9.

Harvest Plus research and implementation (2017).: breeding crops for better nutrition. Washington, DC: Harvest Plus. 2 p. http://r4d.dfid.gov.uk/PDF/ (Outputs/Misc_Crop/ hpRIbro chure.pdf, accessed on 27 May.

Hemalatha, S., Platel, K., & Srinivasan, K. (2007). Influence of germination and fermentation on bio-accessibility of zinc and iron from food grains. European journal of clinical nutrition, 61(3), 342-348.

Henry RW., Elmes, ME., (1975). Plasma zinc in acute starvation. BMJ; 625–626.

Hess, S.Y.; King, J.C. (2009). Effects of maternal zinc supplementation on pregnancy and lactation Outcomes. Food Nutr. Bull. 30, 60–78.

Hooper, P.L., Visconti, L., Garry, P.J. & Johnson, G.E. (1980). Zinc lowers high-density lipoprotein-cholesterol levels. JAMA,. 244: 1960-1962.

Hotz, C., & Brown., K. H. (2004). Assessment of the risk of zinc deficiency in populations and options for its control. International nutrition foundation: for UNU.

Hua Wang1,2,*, Yong-Fang Hu1,*, et. al. (2015). Maternal zinc deficiency during pregnancy elevates the risks of fetal growth restriction: a population-based birth cohort study, China; 08 June.

International Zinc Consultative Group (IZiNCG). (2009). Systematic Review of zinc Intervention strategies. Food and Nutrition Bulletin, 30 (1 Suppl 2): S5-133.

Kenya National Bureau of Statistics (KNBS) or (ICF Macro.) (2010). Kenya Demographic and Health Survey 2008-09. Calverton, Maryland: KNBS and ICF Macro.

Kim EY., Pai TK., Han O. (2011). Effect of bioactive dietary polyphenols on zinc transport across the intestinal Caco-2 cell monolayers.J Agric Food Chem;59:3606-3612.

King, J.C. (2000). Physiology of pregnancy and nutrient metabolism. Am. J. Clin. Nutr., 71, 1218–25.

Klein CJ.(2002). Nutrient Requirements For Preterm Infant Formulas1,2,3. The Journal of Nutrition; 132: 1395-1577. .

Kumera, G., Awoke, T., Melese, T., Eshetie, S., Mekuria, G., Mekonnen, F., & Gedle, D. (2015). Prevalence of zinc deficiency and its association with dietary, serum albumin and intestinal parasitic infection among pregnant women attending antenatal care at the University of Gondar Hospital, Gondar, Northwest Ethiopia. BMC Nutrition, 1(31).

Liao, C. H. et al. (2011) Schizophrenia patients at higher risk of diabetes, hypertension and hyperlipidemia: a population-based study. Schizophr Res..126, 110–116.

Maret, W. (2009). Molecular aspects of human cellular zinc homeostasis: Redox control of zinc potentials and zinc signals. Biometals, 22, 149–157.

Mishra, C. P., & Gupta, M. K. (2011). EDITORIAL: HYPOZINCEMIA: TIME TO ACT. Indian J. Prev. Soc. Med, 42, 112.

Mohamed, A. A., Ali, A. A. A., Ali, N. I., Abusalama, E. H., Elbashir, M. I., & Adam, I. (2011). Zinc, parity, infection, and severe anemia among pregnant women in Kassla, eastern Sudan. Biological trace element research, 140, 284-290.

N Khademl, A Mohammadzadeh2*, AS Farhat2, L Valaee3, M Khajedaluee4, SMR Parizadeh5 (2012). Relationship between Low Birth Weight Neonate and Maternal Serum Zinc Concentration, Iran Red Crescent Med J; 14(4):240-244.

National Academy of Sciences, Institute of Medicine, Food and Nutrition Boards. (2001). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenci, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc; National Academic Press: Washington, DC, USA.

NDUTAH, M. A. (2013). Dietary, socio-economic and demographic factors influencing serum zinc levels of pregnant women at Naivasha level 4 hospital Nakuru County, Kenya (Doctoral dissertation, KENYATTA UNIVERSITY).

Neggers, Y.H., Dubard, M.B., Goldenberg, R.L, Tamura, T., Johnston, K.E., Copper RL., Hauth JC., (1996). Factors influencing plasma zinc levels in low income pregnant women. Biol Trace Elem Res. 55(12):127-235.

Osrin D, de L Costello AM. (2000). maternal nutrition and fetal growth: practical issues in international health. SeminNeonatal;5: 209-19.

Ota, E. et al. (2015). Zinc supplementation for improving pregnancy and infant outcome. Cochrane Data base Syst Rev. 2.

Regassa, K. (2017). Prevalence and associated risk factors of zinc deficiency among pregnant women. A. A, Ethiopia.

Roohani, N., Hurrell, R., Kelishadi, R., & Schulin, R. (2013). Zinc and its importance for human health: An integrative review. Journal of Research in Medical Sciences, 18, 144-157.

Sandström, B. (1997). Bio-availability of zinc. Eur. J. Clin. Nutr., 51(1): 17-19.

Scholl, T.O., Hediger, M. L., Schall, J. I., Fischer, R. L. & Khoo, C. S. (1993). Low zinc intake during pregnancy: its association with preterm and very preterm delivery. Am J Epidem..137, 1115-24.

Seshadri, S. (2001). Prevalence of micronutrient deficiency particularly of iron, zinc and folic acid in pregnant women in South East Asia. British Journal of Nutrition, 85, S87-S92.

Severi C., Hambidge M., Krebs N., Alonso R., Atalah E. (2013). Zinc in plasma and breast milk in adults in pregnancy and postpartum; a cohort study in Uruguay. Nutr Hosp,; 28:223-228.

Shah, D., & Sachdev, H. S. (2001). Effect of gestational zinc deficiency on pregnancy outcomes: observation studies and zinc supplementation trials. British Journal of Nutrition, 85, S101-S108.

Shankar, A.H. & Prasad A.S. (1998). Zinc and immune function: the biological basis of altered resistance to infection. Am. J. Clin. Nutr., 68(l): 447-463.

Simmer K, Thompson RPH. (1985). Maternal zinc and intrauterine growth retardation.Clinical Science. 68:395–399.

Swanson, C.A., King, J.C. (1983). Reduced serum zinc concentration during pregnancy. Obstet. Gynecol., 62, 313–318.

Tamura, T.; Goldenberg, R.L.; Johnston, K.E.; DuBard, M. (2000). Maternal plasma zinc concentrations and pregnancy outcome. Am. J. Clin. Nutr., 71, 109–113.

Ugwuja EI., Akubugwo EI., Ibiam UA., Obidoa O., (2011). Maternal sociodemographic parameters: Impact on trace element status and pregnancy outcomes in Nigerian women. J Health Popul Nutr, 29(2):156-162.

Ugwuja, E. I., Akubugwo, E. I., Ibiam, U., Obidoa, O., & Ugwu, N. C. (2010). Plasma copper and zinc among pregnant women in Abakaliki, Southeastern Nigeria. The Internet Journal of Nutrition and Wellness.

Uriu-Adams JY., Keen CL. (2010). Zinc and reproduction: effects of zinc deficiency on prenatal and early postnatal development. Birth Defects Research Part B, Developmental and Reproductive Toxicology.; 89:313–325.

Walker, C.F., Ezzati, M.,& Black, R.E. (2009). Global and regional child mortality and burden of disease attributable to zinc deficiency. Europ. Journ.of clin.nurt.:63(5), 591-597.

WHO /UNCEF/IAEA/IZiNCG (2007). Executive Summary Recommendation for indicators of population zinc status. Report of Interagency meeting on zinc status indicators. Food Nutr Bull; 28:S399-400[Pub Med][Google Scholar].

Yadrick, M.K., Kenney, M.A. & Winterfeldt, E.A. (1989). Iron, copper, and zinc status: response to supplementation with zinc or zinc and iron in adult females. Am. J. Clin. Nutr.,49: 145-150.

ANNEX'S

Annex's 1:- QUESTIONER SHEET

ADDIS ABABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES CENTER FOR FOOD SCIENCE AND NUTRITION

INFORMATION SHEET

How are you? My name is Gemechu Jofiro. I am from AAU. I was conducting a study on maternal Zinc deficiency during Pregnancy and associated factors. I am here to assess maternal zinc deficiency during pregnancy and associated factors between variables. I would very much appreciate your participation in this study and selected to participate in this study. So you are kindly requested to respond to all statement or questions based on the instruction given. Your information is used only for research purpose and is kept confidential. The following are some general information about the Study.

Objectives of the Study: To assess maternal zinc deficiency during pregnancy and its associated factors among pregnancy mothers in Nifas Silk Lafto Sub-city at selected health centers.

Participants to be included: Participants to will be included in this study are all pregnant mothers those enrolled for first visit ANC during study period.

Confidentiality: All information taken from you will be kept confidential and won't be accessible to any third party; your name won't be registered on the question sheet so that you will not be identified for any reason.

Benefits of the Study: For your participation in the study no payment will be granted or has no any special privilege to you, but participating in the study and giving your genuine information will provide great input to bring change in maternal and infant mortality and morbidity.

Risks of the Study: The procedure does not bear any physical or psychological trauma. Furthermore you will not be forced to respond to information you do not know.

Consent: Your participation in the study will be totally based on your willingness. You have the right not to participate from the beginning, or you may stop participating at any time after starting the participation.

Rights as a Participant: If you have any questions about the Study please be free to ask and contact me. Your participation in this study is voluntary and you can answer any individual question or all of the questions concerning about your health status through during visit follow up. However, I hope that you will participate in this survey since your views are very important.

1. **Informed consent**

Are you voluntary to participate in the interview? Yes No

If Yes, I understand all conditions that stated above. Therefore, I am willing to participate in this study from starting to complements by my:-

Signature ________________________

Name of investigator:- Gemechu Jofiro

Address:- Tell 09 22-51-84-47 **E-mail**:- gemechujofiro12@gmail.com

Name of data Collectors______________________Signature ______________________

Date of data Collection-----------------Started time---------------------Completed time------------------

Result of interview questionnaire:

1. Completed 2. Refused 3. Partially completed

Checked by: Supervisor Name--------------------------Signature----------------Date---------

If no, skip to the next participant by writing reasons for his/her refusal.

Questionnaire

Instruction please answer by putting marking Circle on the listed chooses /fill blank space available as that is appropriate.

Part I: Socio-demographic Characteristic of Study Participants.			
S.No	**Questioners**	**Answers**	**Remark**
001	Age (by years)	--------------	
002	Place from came	from Addis Ababa ☐ Out of Addis Ababa ☐	
003	Religion	Orthodox ☐ Muslim ☐ Protestant ☐ Others(specify)--------	
004	Ethnicity	Oromo ☐ Amara ☐ Others (specify)………	
005	Marital status	Married ☐ others…………	
006	Educational level	Illiterate ☐ Primary ☐ Seconder ☐ Others…………	
007	Job of respondents	Employed ☐ Unemployed ☐	
008	Monthly income (total family income)?	------------------	
009	Monthly cost for food?	------------------	

Part II: Obstetrics Maternal history Information

010	Number of gravid	---------	
011	Number of parity	----------	
012	Gustation age (Trimester)	-----------	
013	Did you have history of abortion?	Yes ☐ No ☐	
014	If yes, for question number '013'. How many times,	----------	
015	Type of abortion	Spontaneous ☐ Induced abortion ☐	
016	Did you have history of still birth?	Yes ☐ No ☐	

017	Did you have history of low birth weight infant through their pregnancy?	Yes ☐ No ☐	

Part III: Maternal Nutritional assessment during ANC visit

	Health related variables	Result	Remark
018	Weight of mothers	....	
019	Height of mothers	....	
020	MUAC	....	
021	BMI	....	

Part IV: Clinical Feature of Mothers

022	Zinc level	....	
023	CRP level	....	
024	Hemoglobin level	....	
025	Morbidity during pregnancy	Yes ☐ No ☐	
026	Have you history of smoking?	Yes ☐ No ☐	
027	Did you take Iron supplementation?	Yes ☐ No ☐	
028	Duration of blood sample collection	Morning ☐ Afternoon ☐	

Part V:- Types of food always you have get and consume

	Food items	Frequently intake	Within 24hrs intake	Remark
029	Teff			
030	Sorghum			
031	Millet			
032	Berbere			
033	Maize			
034	Wheat			
035	Rice			
036	Potato			
037	Sweet Potato			
038	Bean			

039	Pea			
040	Ground nut			
041	Tomato			
042	Carrot			
043	Leafy vegetable			
044	Eggs			
045	Sheep			
046	Goat			
047	Cow/Ox			
048	Fish			
049	Chicken			
050	Milk and milk product			
051	Lemon			
052	Orange			
053	Banana			
054	Papaya			
055	Mango			
056	Avocado			
057	Oils			
058	Honey			
059	Sugar			
060	Coffee			
061	Tea			
062	Sweet beverages			
063	Alcohol			

Annex's 2:- የአማርኛ ጥያቄ የጥናት ፈቃድ ፎርም

ዋና ተመራማሪ፡ ገመቹ ጀፈሮ

እኔ የመጣሁት ከአዲስ አበባ ዩኒቨርስቲ የምግብ ሳይንስና ኒውትሬሽን ማዕከል ሲሆን በአሁኑ ኤምኤስ ሲ ጥናት ስራ ለማጥናት ስለፈለኩት እናንቴ የጥናቱ ተሳታፊ እንዲት ሆኑ በትህትና እጠይቃቸዋለው፡፡

መግቢያ፡ ዚንክ ምግብ የሚገኝ ንጥረ ነገር ስሆን ለሰውነታችን የሚሰጥ ጥቅም ጉልበት እንድናገኝ ይረዳል፡፡ የአስተሳሰብና የመማር ክህሎት በእጂጉ የማጨመር ና የሰዎችን የበሽታ መከላከል ኣቅም የምያጎለብት ነው፡፡ በእርግዝና ጊዜ የተፈጠረው ፅንስ ተጨማረ ዚንክ መጠን ይፈልጋል፡፡ ስለዝህ እናትየዋ በዚህ ጊዜ በቅ ዚንክ ካላገኘች ለተለያየ የጤና እክል ልትዳረግ ትችላለች፡፡ እንዲህም የምጥና ወልድ ጊዜ በተለያየ ችግር ትጋለጣለች፡፡ ለምሳለ ከወልድ በኃላ ደም መፈሰስ፣ ከእርግዚን ጋር የተያየዜ ደም ግፍት፣ ፅንሱ በእራሱ ጊዜ መቋረጥ፤ የፅንሱ እድገት መቀነስ፤ ዝቅተኛ ኪሎ የሆኔ ልጅ መውለድ፤ የምጥ ጊዜ እንድረዝም ያደርጋል፤ ግዜ ያልደረስ ልጅ መውለድ፤ እና ወ.ተ.

የጥናቱ አላማ፡ የዚንክ ማነስ ስርጭት በዕርግዚና ጊዜ ተያይዥ ምክናቶች እና እናቶቸ ና ጽንሱ ላይ ያማጣ ጉዳት ለማጥናት ነው፡፡ በንፋስ ስልክ ላፍቶ ወረዳ 12 ጤና ጣቢያ፣ አዲስ አበባ፣ እትዮጵያ፡፡

የጥናቱ ተሳታፎዎች፡ የጥናቱ ጊዜ ውስጥ በዕጣ የተመረጡ ሁሉም ነፍስጡር ሴቶች ለመጀመሪ ጊዜ የእርግዚና ክትትል የጀምረው እናቶች ናቸው፡፡ ጥናቱ ከመጀመራ ጊዜ የእርግዚና ክትትል ጀምረው እስከ ወልድ ድረስ ነው፡፡

ሚስጥራዊነት፡ የእርስዎ የምርመራ ውጤትም ሆነ መረጃ በየደረጃው ሚስጠራዊነቱ የተጠበቀ ነው፡፡ ጥናቱን የሚያደረጉ ሰዎች ብቻ ናቸው መረጃውን ሊያገኙ የምችሉት፡፡ የናሙና ምርመራ ውጤት የጥናቱ ባለቤት ውጭ ለላ አካል ሊያይ አይችልም፡፡ የጥናቱ ውጤት የሚጻፍበት ግዜ የእርሶ ስም አይጻፍም፡፡

ጥቅሞች፡ የጥናቱ ዉጤት የዚንክ ማነስ ስርጭት በነፍስጡር እናቶች ና ፅንሱ ላይ የማመጣ ችግሮዎች እና ተያይዥ ምክናቶች ለመለየት እንዲህም የነፍስጡር ሴቶችን በዚንክ የበለፀጌ ምግብ ስራአት ለመበጀት ነው፡፡ ባጠቃላይ ነፍስጡር እናቶች ና ፅንሱ ላይ የዚንክ ማነስ እንዳይኖር በየደረጃው ትክክለኛ ፖሊሲ ለመቅረጽና ለመተግበር ይረዳል፡፡

ስጋቶች፡ የምንወስዶ መረጃ ና ናሙናዎች የምረመር ጥናት ብቻ ስለሆኔ ምንም አይነተ ጉዳት አያስከተልም፡፡

መምረያዎች፡ የጥናቱ ጥያቄዎች የሚበሉት ምግብ አይነት ና መጠን፣ የጤና ችግር ከአለዉት፣ የደም ናሙና የመሳሰሉት የተካተቱ ናቸው፡፡

ወጭ፡ በመሳተፍዎ ምንም አይነት ወጭ የለብዎትም፡፡

ካሳ፡ በመሳተፍዎ ምንም አይነት የካሳ አያገኝም፡፡

የተሳታፊዎች መብቶች፡ ግልፅ ያልሆኑ ነገሮች የተኛም ሰአት መየይቅ ይችላሉ፡፡ ተሳትፎ ሙሉ በሙሉ በእርስዎ ፍቃደኝነት ላይ የተመሰረተ ስሆን መወሰን የርሶ ፈንታ ነው፡፡ ለመሳተፍ ካልተስማመ ምንም አይነት ቅጣት የለውም፡፡ የጤና ጣቢያውእና ጤና ባለሙያዎች የተለመደውን የጤና አገልግሎት ይሰጠዎታል፡፡

ጥያቄ ካለዎት ሊጠይቁት የሚፈልጉት ሰው፡ ገመቹ ጆፊሮ

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የጥናቱ ጥቅም በደንብ ተብራርቶኛል እንዲሁም ያለኝ ጥያቄ በደንብ ተመልሶልኛል፡፡ ስለዝህ በዚህ ጥናት ለመሳተፍ ተሰማምቻለሁ፡፡

የጥናቱ ተሳታፊ፡ ፊርማ------------------------ቀን----------------------

የመረጃ ሰብሳቢ፡ ስም----------------------------ፊርማ------------------------ቀን---------------------

የዋናው አጥኚ፡ ስም----------------------------ፊርማ-------------------------ቀን---------------------

የጥያቄ መጠይቃ ቅፅ

ክፍል አንድ፡ ከዝህ በታች የተዘርዘሩትን ህዝብ መረጃ ጥያቄዎች ትክከለኛ መልስ ሰጥኑ ውስጥ ምልከት አደርጉ			
ተ.ቁ	ጥያቄዎች	ምርጫ	ምርማሪ
001	ዕድሜ በዓመት	---------------------------	
002	የመጡበት ቦታ	ከአዲስ አበባ ☐ ከአዲስ አበባ ውጭ ☐	
003	ሃይማኖት	አርቶዶክስ ☐ ሙስልም ☐ ፕሮቴስታንት ☐ ሌላ ከሆነ ግላፅ--------------	
004	ብሔር	አሮሞ ☐ አማራ ☐ ሌላ ከሆነ ግላፅ-------	
005	የትዳር ሁኔታ	ያገባ ☐ ሌላ..................	
006	ትምርት ደረጃ	ያልተማረ ☐1ኛ ደረጃ ☐ኛ ደረጃ ☐ ሌላ...............................	
007	የስራ ሁኔታ	ሥራ ያላት ☐ ሥራ የለላት ☐	
008	አጠቃላይ የወር ገብ (የቤትሰብ)	---------------	
009	በግምት ከማገኙት ገቢ ውስጥ በወር ለምግብ የምያውሉት ምንኃይል ነው?	----------------	

ክፍል ሁለት፡ ከእናቷ የጤና ታሪክ ሁኔታ መረጃ

010	የእርግዝና ቁጥር ቢዛት	---------------	
011	የወለደች ልጆች ቢዛት	---------------	
012	የእርግዝና ወቅት በወር	------------------	
013	ከዝህ በፍት ውረጂያ አለሽ ?	አዎ ☐ የለኝም ☐	
014	ተራ ቁጥር 013 መልሱ አዎ ከሆኔ. ስንት ጊዜ ውርጂያ አለሽ ?	--------------	
015	የውርጂያ አይነት	በእራሱ ጊዜ የወረደ ☐ በእሠሱዋ ፍላጎት የወረደ ☐	
016	ሞቶ የወለደ ልጅ አለሽ ?	አዎ ☐ የለኝም ☐	
017	አነስታኛ ኪሎ የሆኔ ልጅ ወልደሽ ተቃለሽ?	አዎ ☐ የለኝም ☐	

ክፍል ሦስት፡ በክትትል ጊዜ ደስሳ ምርመራ

018	የእናቷ ክብደት	----------	
019	የእናቷ ቁሜት	--------	
020	የእናቷ ጡምቻ መሃል ላይ መለካት	----------	
021	ቦድ ማስአንደክስ(BMI)	-----------	
ክፍል አራት፡ በክትትል ጊዜ የታዩት የጤና ሁኔታ መረጃዎች			
022	የዚንክ መጠን	---------	
023	የሲ. ራ ፒ መጠን	---------	
024	የሄሞግሎብን መጠን	---------	
025	ያገጠሜ የጤና ችግር አለው ::	አዎ ☐ የለኝም ☐	....
026	የስጋራ መጨስ ሱስ አብለሽ?	አዎ ☐ የለኝም ☐	

027	የደም ማነስ መደሀንት እየወሰርሽ ነው ?	አዎ ☐ የለኝም ☐		
028	የደም ናሙና የተወሰዴለት ግዜ	ጡዋት ☐ ከሳአት ☐		
ከፍል አምስት፡ አብዜኛ ጊዜ የምበሉት የምግብ አይኔት ሳጥኑ ውስጥ ምሊክት አይርጉ				
	የምግብ አይኔት	ተደጋገም ትወስዳለሽ	24 ሰአት ውስጥ ወስደሻል	
029	ጤፍ			
030	ዘንጋዳ			
031	ዳጉሳ			
032	በርበሬ			
033	ስንዴ			
034	በቆሎ			
035	ኑገ			
036	ድንች			
037	ስኳር ድንች			
038	ባቄላ			
039	አተር			
040	ቲማቲም			
041	ካሮት			
042	ቅጠላቅጠል			
043	እንቁላል			
044	የአሳ ሥጋ			
045	የበግ ሥጋ			

046	ፍየል ሥጋ			
047	የባሬ ሥጋ			
048	የዶሮ ሥጋ			
049	ወተትና ወተት ተዋፆኦ			
050	ሎሚ			
051	ብርቱካን			
052	ሙዝ			
053	ፓፓያ			
054	ማንጎ			
055	አቮካዶ			
056	ዘይት			
057	ቅቤ			
058	ማር			
059	ስኳር			
060	ቡና			
061	ሻይ			
062	ጣፋጭ ፈሳሽ /ላስላሳ			
063	መጠጥ			

Annex's 3:- Zinc concentration physiological requirement for absorption age groups & sex

Variables Age	WHO Reference Wt. (kg)	WHO Requirement (mg/day)	Variables Age	FNB Reference Wt. (kg)	FNB Requirement (mg/day)	IziNCG Reference Wt. (kg)	IziNCG Requirement (mg/day)
6-12 mo	9	0.84	6-12 mo	9	0.84	9	0.84
1-3 year	12	0.83	1-3 year	13	0.74	12	0.53
3-6 year	17	0.97	4-8 year	22	1.20	21	0.83
6-10 year		1.12		25			
10-12 year	35	1.40	8-13 year	40	2.12	38	1.53
12-15 year				48	1.82		
15-18 year M	64	1.97	14-18 year M	64	3.37	64	2.52
15-18 year F	55	1.54	14-18 year F	57	3.02	56	1.98
Pregnancy	-	2.27	Pregnancy *	-	4.1-5.0	-	2.68
Lactation	-	2.89	Lactation*	-	3.8-4.5	-	2.98

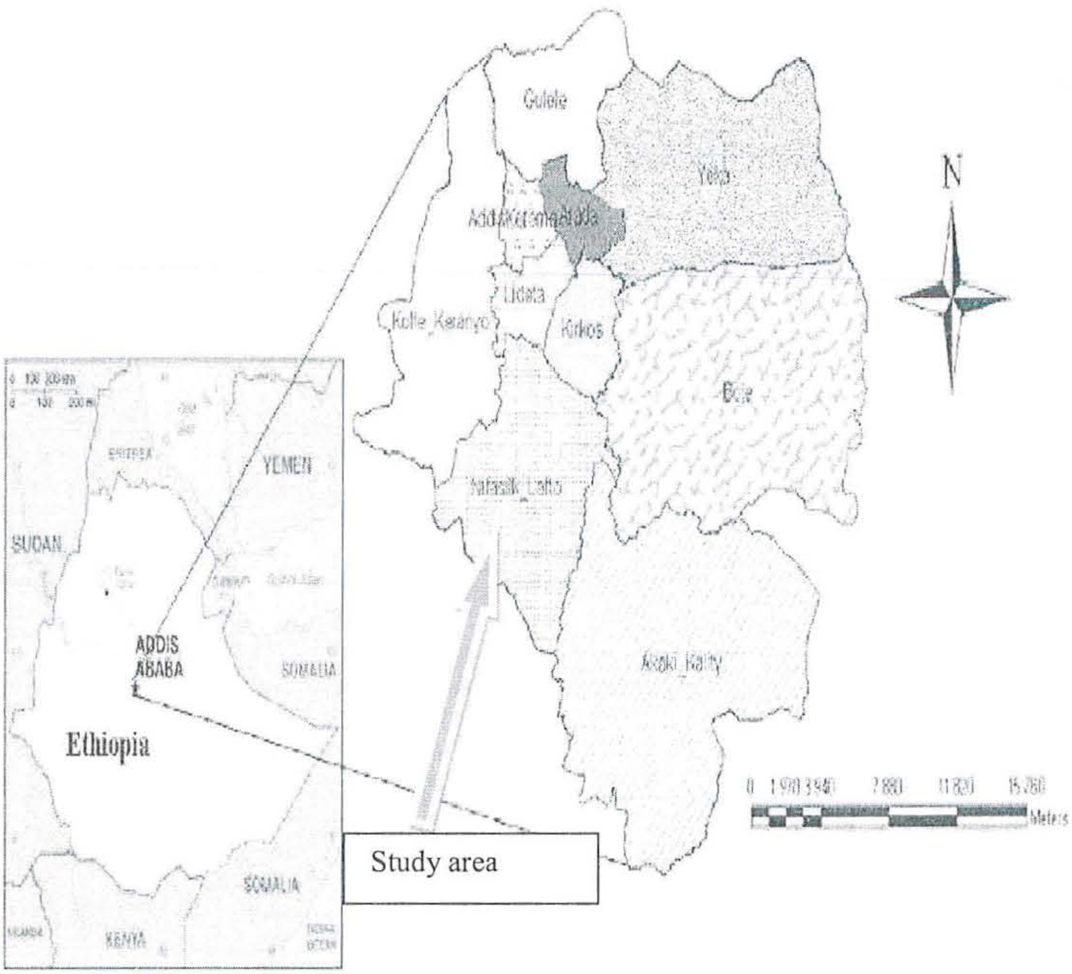
*Different stages of pregnancy/lactation.

Annex's 4:- Regional means ±SD for national data on daily per capita energy

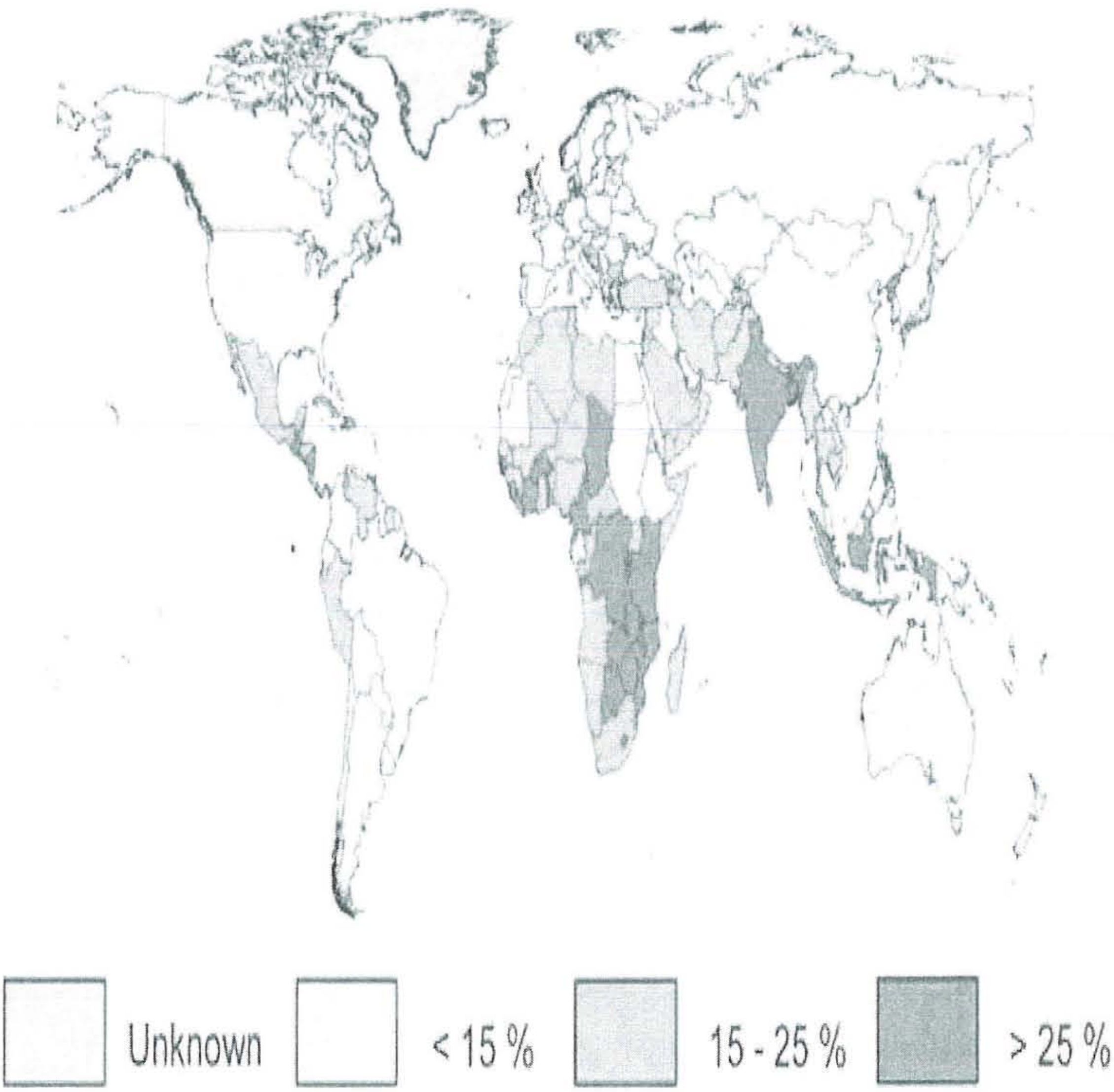
VARIABLE	High-Income	South AndTropical L America	China	Central and Eastern Europe	Central and Andean L. America and Carib	Central Asia, North Africa and middle East	East and south east Asia and pacific	Sub Saharan Africa	South Asia	Global
Number of countries	30	5	3	20	27	28	21	48	6	188
Population (millions)	937.2	249.4	41337.7	330.1	301.4	481.4	606.8	757.8	1495.6	6497.5
Energy (kcal)	342±323	3031±88	2905±65	3286±175	2836±468	3089±359	2585±170	2351±345	2281±31	2776±472
%of energy from ASF	27.6±5.1	23.2±2.8	21.0±1.2	23.1±2.9	16.3±3.8	11.9±4.3	10.1±4.2	6.8±5.0	9.0±4.0	15.8±8.4
Zinc (mg)	13.2±1.3	12.3±0.9	13.6±0.5	11.7±1.1	10.7±3.1	13.9±3	8.9±1.3	8.4±1.7	9.8±0.7	11.4±2.5
Zinc density (mg/100kcal)	3.9±0.3	4.1±0.3	4.7±0.1	3.6±0.3	3.7±0.6	4.5±0.8	3.4±0.4	3.6±0.5	4.3±0.3	4.1±0.6
% of zinc from ASF	59.7±8.5	59.7±7.2	49.2±2.3	51.8±4.2	39.7±9.7	23.7±11.1	28.0±10.7	19.1±11.6	11.5±4.9	34.8±20.0
Phatate (mg)	1173±173	1170±245	1456±18	1199±210	1887±929	2776±1089	1440±165	1782±499	2559±226	1730±649
Phatate :zinc molar ratio	9.0±2.2	9.6±2.3	10.6±0.8	10.1±1.3	16.6±4.6	19.1±4.5	16.4±3.1	21.3±4.4	22.8±1.1	15.8±6.2
Est. fractional absorption	0.25±0.01	0.26±0.01	0.23±0.0	0.27±0.02	0.26±0.07	0.19±0.05	0.28±0.02	0.27±0.04	0.23±0.02	0.24±0.04
Absorbable zinc (mg)	3.32±0.28	3.21±0.32±	3.17±0.09	3.10±0.13	2.53±0.21	2.56±0.24	2.46±0.26	2.17±0.28	2.19±0.05	2.71±0.51
% mean physiological requirement	160.8±14.7	164.3±15.5	155.4±4.7	149.2±6.7	133.0±9.7	133.4±12.2	127.3±14.6	123.04±14.5	115.7±4.1	138.0±20.
Est. % of pop. With inadequate zinc intake	7.5±4.1	6.4±1.8	7.8±2.1	9.6±2.4	17.0±5.9	17.1±5.4	22.1±10.0	25.6±12.2	29.6±3.6	17.3±11.1

Annex's 5:-

Map of Addis Ababa (source: https://www.researchgate.net/publication/281460707)

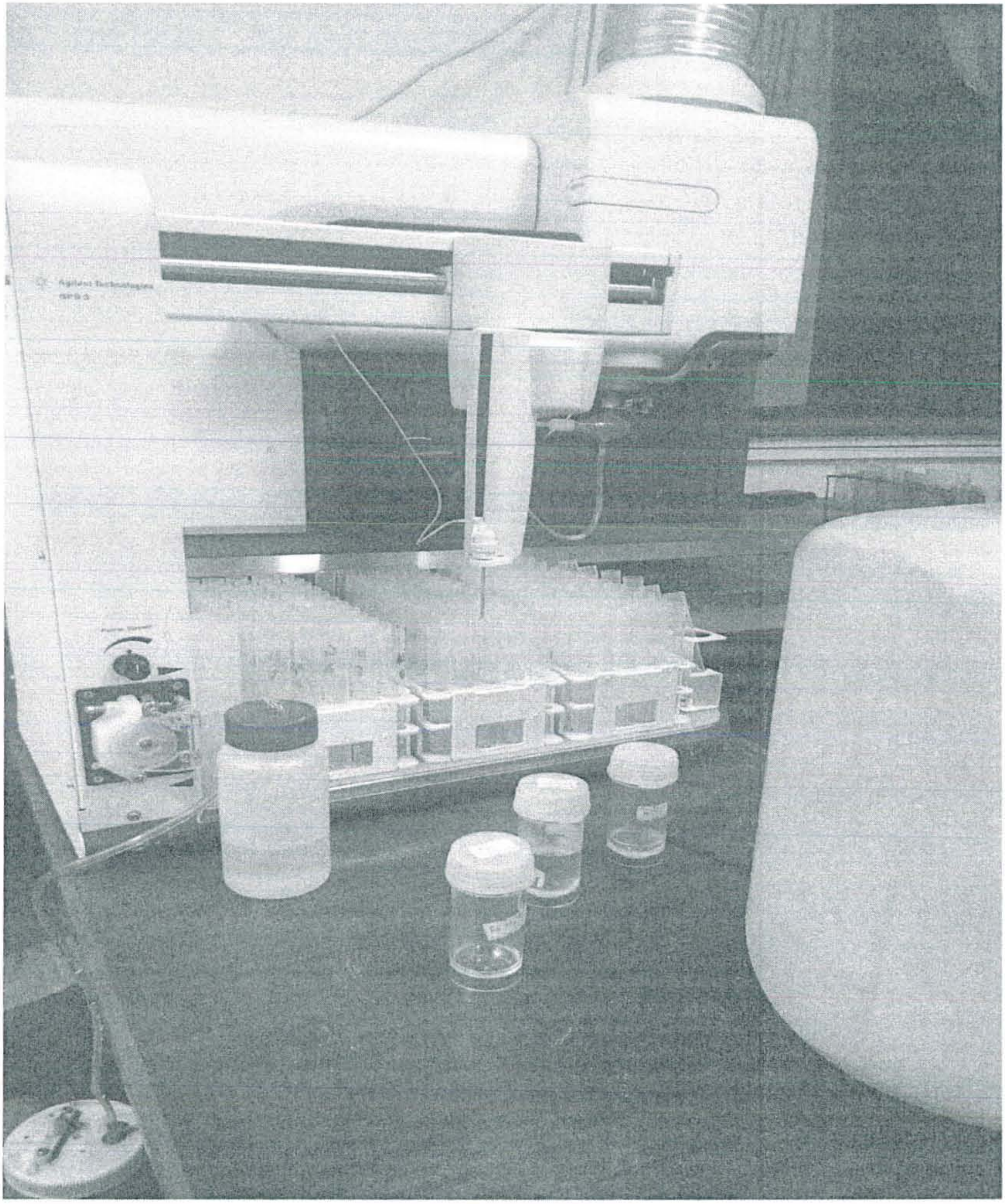


Annex's 6:- Estimated country specific prevalence of zinc deficiency (source Wessells et al.2012)

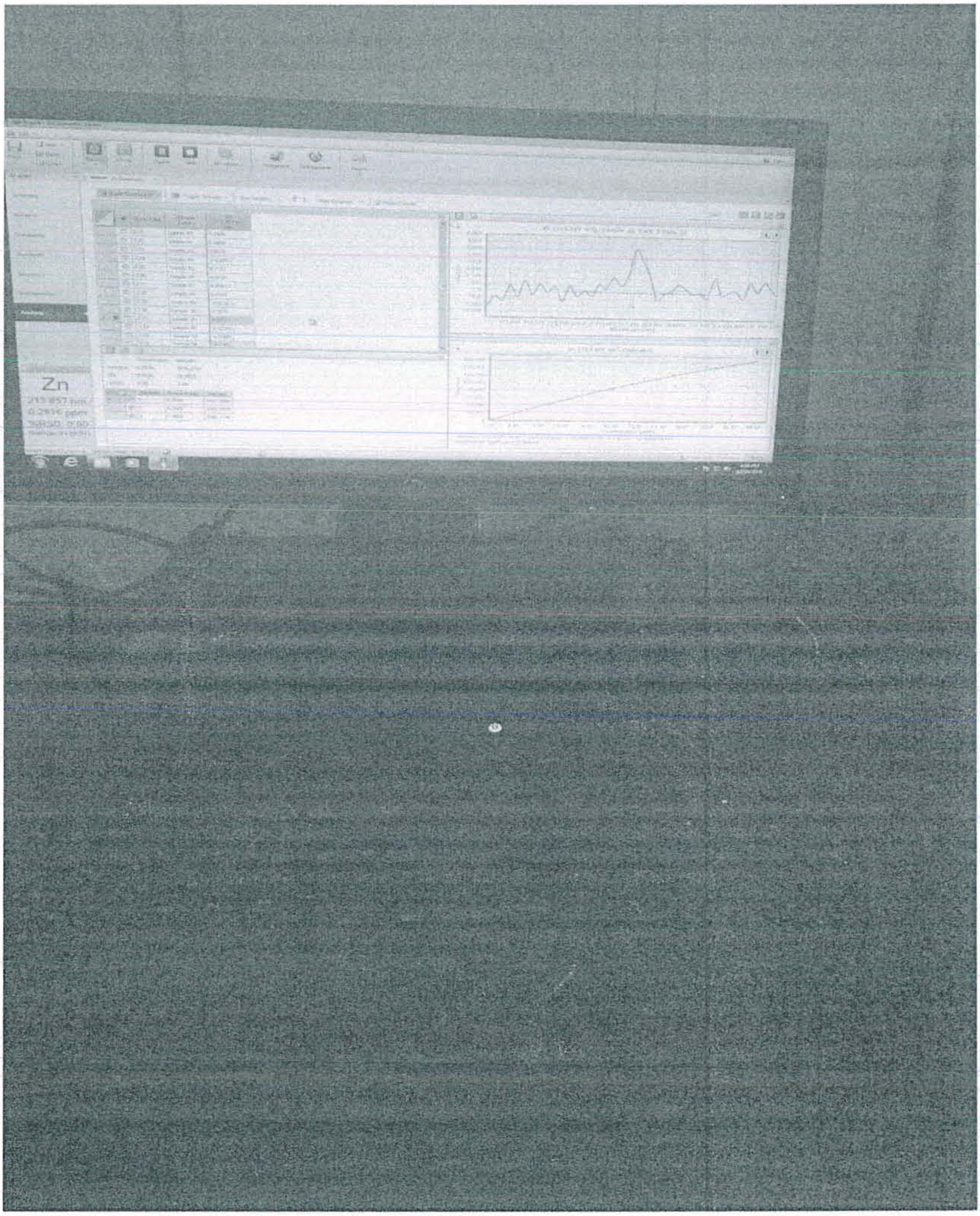


Annex's 8:- Serum sample separation, storage and transport

Annex's 9:- Zinc analysis

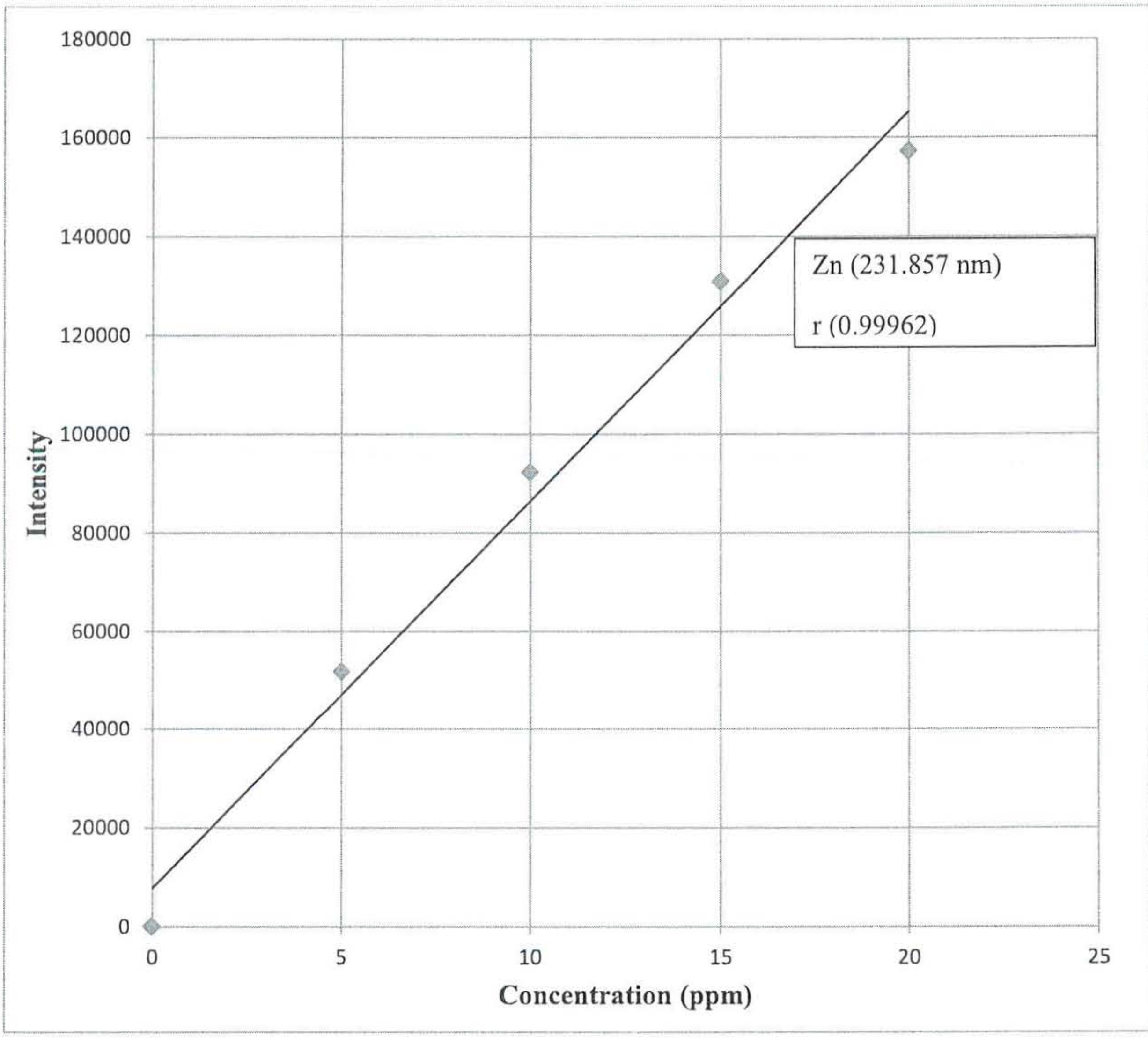


Annex's 10:- Reading result after serum analysis



Annex's 11:- Calibration Curve

Zn (231.857 nm) Calibration Curve



Annex's 12:- Operational definitions

Dietary diversity:-

This is the qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals.

Dietary diversity score:-

Dietary diversity score is the total sum of the different food groups, consumed by the study participants within 24hrs preceding survey.

Women dietary diversity score:-

It is a reflection of the probability of micronutrient adequacy of the diet and the food groups included in the score are tailored towards this purpose. While twelve groups are included in the house hold dietary diversity, nine food groups are included in women dietary diversity with the micronutrients intakes in consideration (FAO, 2011).

Dietary factors:–

These are the factors related to dietary intake of zinc and other nutrients. They include dietary zinc intake, dietary diversity and food consumption practices during pregnancy.

Socio-economic Status:-

Defined by proxy indicators and ownership of properties e.g. source of income and occupation.

Demographic factors:-

These are the factors associated with the demographic characteristics of the study participants. They include parity, age, education level and marital status.