Vitamin A Deficiency in Ethiopia:
Magnitude, Distribution and Potential Risk Factors

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To my wife Abebech Demissie and my son Geleta Tsegaye

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Paper II:

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Paper III:

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Paper IV:

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ABSTRACT

Background

Based on the high vitamin A deficiency rates indicated in the reports of several pocket level surveys, it can be concluded that vitamin A deficiency is a major public health problem exacerbating child morbidity, mortality and disability in Ethiopia. In order to effectively address the problem, up-to-date and comprehensive information is imperative.

Objective of the thesis

The aim of the research is to provide up-to-date and disaggregated information on the magnitude and determinants of vitamin A deficiency in Ethiopia that are deemed important in the prevention and control efforts.

Methods

The national survey, the major component of the research, employed cross-sectional study design and multi-stage cluster-sampling approach. A total of 23,148 children were examined for the clinical signs and symptoms of vitamin A deficiency. Blood was collected from 1200 children for serum retinol analysis and a questionnaire addressing most of the potential determinants of vitamin A deficiency was administered to 2552 households. Assessment of risk factors to vitamin A deficiency among primary school children employed a case-control study design and included 97 clinical cases and 194 controls. In addition, analysis of beta carotene contents of fifteen food items, five each from common vegetables, common fruits and common staple foods was done.

Results

The survey revealed high prevalence rates of vitamin A deficiency across the country. The national bitot's spot prevalence rate was 1.7% with the highest rates in the Amhara Region (3.2%), followed by the prevalence rates in Afar (2.1%), Oromiya (1.5%), Addis Ababa (1.4%), Harari (1.2%) and Dire Dawa (1.1%). The national maternal night blindness prevalence rate was 1.8% with the high prevalence rates in Tigray (14.1%), Benishangul-Gumuz (5.7%), Afar (1.2%) and Amhara (1.0%). The national weighted prevalence rate of subclinical vitamin A deficiency (<0.7µmole/lt) was 37.7% (95% CI; 35.6%-39.9%), with high prevalence rates in Afar (57.3%) and Oromiya regions (56.0%), moderate prevalence rates in Dire Dawa (48.0%), Amhara (40.7%) and Harari (35.3%) regions and relatively low prevalence rates in Tigray (14.3%) and SNNP (11.3%) regions.

Among the under-six children, male children and older children were affected more by clinical vitamin A deficiency than female children and young children ($p<0.05$). The prevalence of clinical vitamin A deficiency was significantly higher among children from predominantly rural areas compared to that of children from predominantly urban areas ($p<0.05$). Being from Muslim households (OR = 2.23), belonging to mothers who could not mention at least one fact about vitamin A (OR = 1.80), not receiving vitamin A supplement at least once in the previous year (OR = 1.45), belonging to mothers who have given birth to three or more children (OR=1.46) and being sick in the two weeks preceding the survey (OR=1.42) were found to have been associated with high levels of subclinical vitamin A deficiency among preschool age children. Similarly, being from Muslim households (OR = 7.03), not consuming vegetables three or more times a week (OR=3.04) and being sick in the two weeks preceding the survey (OR=2.04) were associated with high levels of clinical vitamin A deficiency among primary school children.

In aggregate, 41.5% of the studied households did not produce/cultivate any of the common vegetables over the year preceding the survey and the proportion was high in Addis Ababa (99.7%), Afar (94.9%), Dire Dawa (94.2%), Tigray (86.4%) and Harari (63.1%) regions. Similarly, 75.5% of studied households did not cultivate/produce any of the common fruits over the year preceding the survey and the proportion was high in Addis Ababa (100%), Dire Dawa (95.3%), Afar (92.9%), Tigray (92.2%), Harari (83.3%) and Oromiya (81.8%) regions.

Overall, 38.1% of the children studied did not eat any of the common vegetables over the week preceding the survey and the proportion was high in Afar (85.0%), Tigray (77.6%), Amhara (61.8%) and Addis Ababa (59.3%). Similarly, 36.5% did not eat any of the common fruits over the week preceding the survey, with the highest proportions in Tigray (88.1%) and Afar (83.5%) regions. Over 66% of the children included in the study did not eat meat, close to 53% of the children did not eat eggs and 33.4% of the households included in the study did not use oil over the week preceding the survey. The situation regarding own production of fruits and vegetables was significantly better ($p<0.05$) in predominantly rural areas whereas market availability and consumption of fruits, meat, egg and oil was significantly better ($p<0.05$) in predominantly urban areas.

High beta carotene content in kale (6100.45 μg/100gm) and carrot (5800.09 μg/100gm), moderate amounts in spinach (800.12 μg/100gm), mango (500.54 μg/100gm) and papaw (800.86 μg/100gm) and no or negligible amounts in injera, bread and kocho were observed.

Conclusions and recommendations

Conclusions

The study revealed that, albeit the longstanding effort to control and eradicate vitamin A deficiency in Ethiopia, the problem is still prevailing unabated. Although the prevalence of vitamin A deficiency (clinical and subclinical) were higher than the WHO cut off points in all regions, the extent of the problem in Amhara, Afar and Oromiya regions appears to be more serious. Again, although vitamin A deficiency (clinical) was significantly higher in predominantly rural areas compared to predominantly urban areas, prevalence rates in Addis Ababa, Harari and Dire Dawa (predominantly urban areas) were found to constitute a public health concern. The study highlighted the increased risk of Muslim preschool and school children, male and older preschool age children to vitamin A deficiency compared to their respective counterparts. The negative impacts of morbidity, enormous benefits of vitamin A supplementation and the strong positive contributions of maternal awareness to vitamin A status of children were underlined in the study. Moreover, the strong association of vegetable consumption with vitamin A deficiency among primary school students was also underscored. The study, however, showed that the practice of planting/cultivating and consumption of common vegetables and fruits was suboptimal in Ethiopia.

Recommendations

Policy and strategy related recommendations

- Agricultural policies and strategies that facilitate production of fruits, vegetables and livestock products must be developed and implemented.
- School health and nutrition policy and strategy to enhance the awareness of the students regarding the importance of vitamin A must be developed.

Intervention related recommendations

- Continuation and intensification of the ongoing periodic vitamin A supplementation by ensuring universal coverage, its timeliness and safety is recommended.
- Strengthening attempts aimed at enhancing the consumption of vegetables, fruits, oil and livestock products are recommended.
- Strengthening efforts to improve women's awareness regarding the importance of vitamin

A is recommended.

- Priority and attention must be given to Amhara, Afar, Oromiya and Harari regions and Addis Ababa and Dire Dawa city administrations.
- Interventions aimed at improving maternal vitamin A nutrition, particularly, postpartum vitamin A supplementation is recommended.

Surveillance related recommendations

- Mechanisms to monitor vitamin A status must be established.
- Conducting serial cross-sectional surveys at national, regional and sub-regional level periodically (e.g. in 5 years interval) using biological indicators is recommended

Research related recommendations

- The increased risk of Muslim preschool and primary school children to vitamin A deficiency merit an in depth and well designed investigation.
- Similarly, the increased risk of male and older preschool age children to clinical vitamin A deficiency requires further in-depth assessments to expound the reasons.
- Investigation on the reasons why Ethiopians do not adequately produce and consume vegetables and fruits is recommended.

Key words: Clinical vitamin A deficiency; sub-clinical vitamin A deficiency; serum retinol levels; Ethiopia

ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
BCC	Behavior Change Communication
BDL	Below Detection Level
CFR	Case-Fatality Rate
CSA	Central Statistical Agency
DGLV	Dark Green Leafy Vegetables
EEOS	Extended Enhanced Outreach Strategy
EHNRI	Ethiopian Health and Nutrition Research Institute
ENI	Ethiopian Nutrition Institute
EOS	Enhanced Outreach Strategy
EPI	Extended Program on Immunization
EPIINFO	Epidemiological software for sampling, data entry and analysis
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agriculture Organization
FMoH	Federal Ministry of Health
HIV	Human Immunodeficiency Virus
HPLC	High Performance Liquid Chromatography
ICNND	Inter-departmental Committee on Nutrition for National Defense
IDD	Iodine Deficiency Disorders
IEC	Information, Education and Communication
IVACG	International Vitamin A Consultative Group
MCH	Mother and Child Health
NNP	National Nutrition Program
NID	National Immunization Days

OR	Odds Ratio
RDA	Recommended Daily Allowances
RE	Retinol Equivalent
RTI	Respiratory Tract Infection
SDA	Simplified Dietary Assessment (SDA)
SNNPR	Southern Nations, Nationalities and People's Region
SPSS	Statistical package for social sciences
UNICEF	United Nations Children's Fund
VA	Vitamin A
VAD	Vitamin A Deficiency
VAS	Vitamin A supplementation
WHO	World Health Organization
WIBS	Woreda Integrated Basic Services
XN	Night blindness

1. INTRODUCTION

1.1. Sources and requirements of vitamin A

Vitamin A is one of the essential nutrients required in small quantities for several metabolic activities in the body. It is found as preformed vitamin A (retinoids) in animal tissues and provitamin A (carotenoids) in plant tissues (1,2). Among the animal foods, human milk, meat, liver, fish liver oils, egg yolk and whole milk are good sources of preformed vitamin A. Green leafy vegetables (e.g., spinach, amaranth, and young leaves from various sources), yellow vegetables (e.g., pumpkins, squash, and carrots), and yellow and orange fruits (e.g., mangoes, apricots, and papaya) contain higher amounts of pro-vitamin A (2). Red palm oil produced in several countries worldwide is especially rich in pro-vitamin A (3).

Although provitamin A (carotenoids) from plat sources tend to be less bio-available, they are however, more affordable than animal products. Thus, most of the economically deprived populations in developing countries depend on plant sources. It is estimated that over 80% of vitamin A in developing countries is supplied by fruits and vegetables (1). Bio-availability of vitamin A in foods from plant sources depends on several factors, such as species of carotenoids, amount of carotenoids consumed in a meal, effectors of absorption and conversion (such as fats and proteins), nutritional status and other host related factors (1). To express the vitamin A activity of carotenoids in diets on a common basis, a joint FAO/WHO Expert Group in 1967 introduced the concept of the retinol equivalent (RE) and suggested that 6 units of beta-carotene and 12 units of other provitamin A (carotenoids) should be considered as equivalent to 1 unit of retinol (4). These equivalences were derived from balance studies that examined the efficiency of digestion and absorption of carotenoids in human body. There is a continuing investigation and ongoing debate about the correctness of the conversion factors. It appears that no consensus has been reached so far and until such consensus is reached, the use of aforementioned conversion factors will continue (5-7). Requirement of vitamin A is based on the considerations of the impacts of hypovitaminosis A and potential toxic effects of hypervitaminosis A. As vitamin A is essential for several metabolic activities its deficiency is associated with severe health consequences. Thus, minimum requirements are set in view of preventing the consequences of vitamin A deficiency. In the other extreme, vitamin A is known to cause toxicity at higher levels and therefore safe levels are set in view of preventing toxic effects. The range between the minimum requirement and safe levels constitute the daily requirements. In addition, as the demand for vitamin A varies among various groups of population, the daily requirements also vary by age, sex and physiological status. In the following table, FAO/WHO recommended daily requirements are shown (4)

Table 1: Estimated mean requirement and safe level of intake for vitamin A

Sex and physiological status	age	Mean requirement (µg RE/day)	Recommended safe intake (µg RE/day)
Infants and children	0-6 months	180	375
	7-12 months	190	400
	1-3 years	200	400
	4-6 years	200	450
	7-years	250	500
Adolescents	10-18 years	330-400	600
Female adults	19-65 years	270	500
Male adults	19-65 years	300	600
Elderly	≥65 years	300	600
Pregnant women		370	800
Lactating women		450	850

Source: reference # 4

1.2. Functions of vitamin A

Through normal digestive processes, carotenoids and retinoids are freed from the embedding food matrices and pass in to intestinal mucosal cells. In the mucosal cells of the intestine, the carotenoids, especially the beta carotene is converted in to two retinyl groups by beta-carotene dioxygenase enzyme, and the retinyl group combines with various carrier proteins and delivered to the circulatory system. Target cells then extract retinol from the carrier proteins (8-11).

It is well established that vitamin A is important for vision in less illuminated conditions. In the retina, rhodopsin, the visual pigment critical to dim-light vision is formed when retinol combines with membrane bound rod cells. Alteration of rhodopsin through a cascade of photochemical reactions results in ability to see objects in dim light (12). It is also well substantiated that vitamin A plays a key role in the growth and differentiation of epithelial cells throughout the body. In particular, vitamin A plays an important role in the normal differentiation of goblet cells in the epithelium (mucus producing cells) that maintain the integrity of epithelial tissue, crucial in preventing the passage of pathogens to internal organs (13-15). Studies have also shown that Vitamin A regulates the production and normal functioning of the specific immune system (16); that it plays a role in the production and maintenance of white blood cells and lymphocytes (14, 15) and that it plays a hormone like function in regulating the expression of several genes that control the synthesis of a large number of proteins vital in maintaining normal physiologic functions in the body (17).

Dietary intake studies suggest an association between diets rich in vitamin A and a lower risk of many types of cancers (18). High intake of green and yellow vegetables or other food sources of beta carotene and/or vitamin A is believed to reduce the risk of lung cancer because, as a strong antioxidant, vitamin A protects the cells from free radicals that cause cancer (19, 20). The strong association of vitamin A deficiency with anemia observed in some studies suggests that vitamin A is important for the transport and metabolism of iron (21-23). Similarly, the correlations of vitamin A deficiency with iodine deficiency reported in some studies tend to suggest that vitamin A deficiency influences iodine metabolism as well (24, 25).

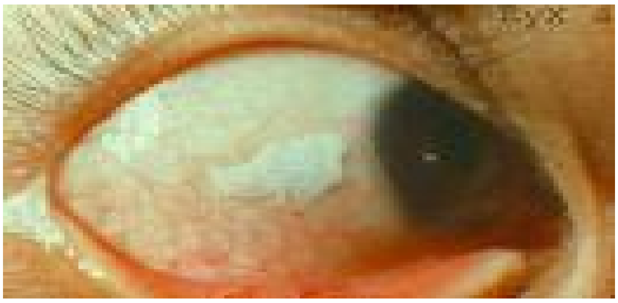
There is also a hypothesize suggesting that vitamin A plays some role in reproduction, skeletal development and energy balance. The list of roles and functions of vitamin A is increasing and it is speculated that with the advancement of cell biology more and more functions of vitamin A will be elucidated (1).

1.3. Consequences of vitamin A deficiency

One of the major consequences of vitamin A deficiency is impaired visual functions. Vitamin A is the constituent part of the rods and cons cells in the retina. As mentioned earlier, the combination of retinol and rods cells enables the retina to adjust and see in dim lights. Thus, lack of adequate vitamin A in the body deprives the capacity to see in dim light, the condition known as night blindness. Children with night blindness are scared to roam around in less illuminated conditions or bump into things when they roam. Night blindness is one of the earliest signs of vitamin A deficiency and in ancient Egypt, it was known that night blindness could be cured by eating liver, which was later found to be a rich source of the vitamin (26).

With increasing deficiency states, series of clinical signs and symptoms develop in the eyes, which are collectively known as xerophtalmia (1, 27). The first sign is the dryness of conjuctiva which is referred to as conjuctival xerosis. Although dryness of epithelial cells occurs anywhere in the body, it is more discernable on the eye and more deleterious in the internal organs. With the heaping up of keratin debris as a result of dryness of conjuctiva, white cheesy or foamy spots develop which are known as bitot's spots. Bitot's spot's are usually found in the temporal part of the conjuctiva and most often one spot is found per eye.

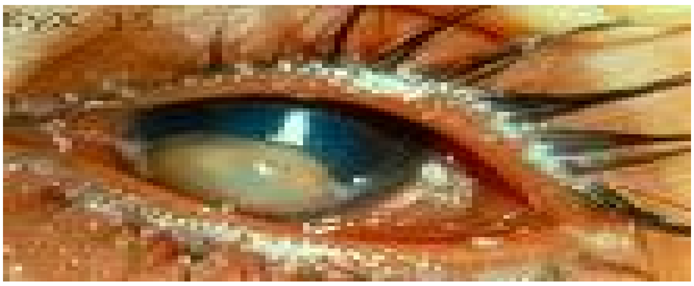
Fig 1: Bitot's spot



Source: Reference # 27

With sustained deficiency state, the disease progresses to the cornea. Cornea becomes dry (corneal xerosis) and ulcers develop (corneal ulceration/keratomalacia). Ulcerations usually begin as a single spot and widen to cover the whole cornea, leading to protrusion and ultimately to blindness. It has been implicated that vitamin A deficiency is the major cause of blindness in developing countries (1). When corneal ulcers are healed, scars are left on the cornea, with inevitable loss of all or some sight.

Fig 2: Corneal ulcerations or keratomalacia



Source: reference # 27

As it was mentioned earlier, vitamin A plays an important role in the normal cellular differentiation. It plays a key role in the secretion of mucus which is essential for maintaining cellular integrity by protecting the epithelial tissue from dryness and breakage. When vitamin A is inadequate in the body, the mucus secreting cells are replaced by keratin producing cells that cause dryness and breakage of the epithelial tissue allowing infiltration of pathogens. Studies have shown that milder degrees of vitamin A deficiency without obvious clinical manifestations increases the risk of developing respiratory and diarrheal infections, decrease growth rate, slow bone development, and decrease likelihood of survival from serious illness (28, 29). In the overall, studies have clearly demonstrated that by improving Vitamin A status, mortality of children can be reduced by 23% (30) and maternal mortality by as much as 40% (31).

High level of vitamin A in the body is known to entail toxicities as mentioned earlier. Because, vitamin A is fat soluble that can be stored, primarily in the liver, routine consumption of large amounts of vitamin A over a short period of time has been found to result in toxic symptoms, including liver damage, bone abnormalities and joint pain, alopecia, headaches and vomiting and skin desquamation (32). Toxicity is more often associated with supplementation of high levels of vitamin A once or in short period of time. Studies have shown that very high single doses can cause transient acute toxic symptoms that may include bulging fontanels in infants; headaches in older children and adults; and vomiting, diarrhea, loss of appetite, and irritability in all age groups (33). An excess of bulging fontanels occurred in infants under 6 months of age in one endemically deficient population given two or more doses of 7500 mg or 15 000 mg preformed vitamin A in oil (33, 34). When taken by women at early stages of gestation at daily levels of more than 7500 mg (25 000 IU), fetal anomalies and poor reproductive outcomes have been observed (35).

1.4. Indicators and Assessment of Vitamin A Status

Four methods are commonly used in assessing vitamin A status of a community/population. These are assessment of signs and symptoms of vitamin A deficiency (clinical assessment), assessment of the levels of retinol in the body (the subclinical or biochemical assessment), assessment of the adequacy of vitamin A in the foods consumed (dietary assessment) and assessment of the vitamin A associated risk factors such as nutrition, health and socio-demographic factors (ecological and related factors).

1.4.1 Assessment of clinical signs and symptoms

Night blindness: In young children, the major vulnerable group of VAD, direct observation and an interview has usually been used to assess night blindness (36). A standardized interview for the child's guardians has been developed. The presence of terms in local languages in endemic areas makes the interview simpler and more accurate. These are often descriptions of poor vision at dusk such as "night eyes" and "chicken eye". If the child is old enough to walk, it may be seen as he/she stumbles in a room at dusk, or fail to grasp things that he/she wants to grasp.

Conjuctival and corneal xerosis: Direct observation (clinical examination) has been the main technique in assessing the conjuctival and corneal xerosis. The use of the findings obtained through direct observation is somewhat limited, as xerosis covers a wide spectrum in intensity and features that can not easily be standardized among investigators. Again since dryness of the eye is caused by a number of other factors that are not etiologically related to VAD (especially eye infections which are frequent in developing countries) the use of the observation results has been limited (1,27).

Bitot's spot: The only procedure to assess bitot's spot is by examining the eye. The fact that VAD unrelated bitot's spot is very rare, makes bitot's spot relatively reliable and sensitive indicator of vitamin A status. It is also relatively easily and correctly identifiable and standardizeable indicator (1, 27).

Corneal ulcerations or keratomalacia: Clinical examination/observation is the commonly employed means to assess corneal ulcerations/keratomalacia. Since corneal ulcerations/ keratomalacia can arise due to non VAD related causes, interpretation of the results must be made cautiously, especially the agro-ecological, health and nutrition conditions must be considered in the interpretation of the results (37, 38).

Corneal scar: The corneal scar is assessed by examination and should be considered as VAD related only if it is nasal and inferior, bilateral with varying sizes and onset is between 2 months and five years (1, 27).

Codes used for clinical indicators and their respective cut off points recommended:

In 1982 expert groups convened by WHO (37) reviewed and endorsed the definition/codes of various stages of clinical signs/symptoms of vitamin A deficiency and set the minimum prevalence rates that should be used to identify the at risk community/population (Table 2). It is recommended that when the prevalence rate exceeds the cut off points set, the population must be considered at risk population and actions must be initiated to mitigate the problem.

Table 2: Codes and criteria for assessing the public health significance of vitamin A deficiency.

Sign/symptom and codes	**Minimum prevalence**
Night blindness (XN)	1.0%
Bitot's spot (X1B)	0.5%
Corneal xerosis (X2); Ulceration (X3A[1]); Keratomalacia (X3B) (X2+X3A+X3B)	0.01%
Xerophthalmia-related corneal scars (XS)	0.05%

Source: reference # 27

1.4.2. Biochemical assessment of vitamin A status (subclinical)

The level of retinol in the blood is regulated within a narrow range of 0.7- 2µmol/l, which is considered as a normal range. Direct and indirect means to measure the level of circulating retinol or techniques to measure the amount of stored retinol in the liver constitute the essence of biochemical assessment/subclinical assessment (1).

Serum retinol: Serum retinol levels are directly determined from the blood. In the past it has usually been considered that a serum retinol level <0.35 µmol/l was "deficient" and <0.70 µmol/l was "low". The WHO 1996 consultative group recommended to retain the "low" value at 0.70 µmol/l and to consider this consistent with the presence of a subclinical deficiency state at the individual level. The consultative group proposed the following cut-off points to be considered in the assessment of subclinical vitamin A status of populations (38).

Table 3: Cut off prevalence of serum retinol levels indicative of public health significance

Prevalence	Severity
Less than 2% of the preschool age children below 0.70 µmol/l	Normal
2-10% of the preschool age children below 0.70 µmol/l	Mild
10-20% of the preschool age children below 0.70 µmol/l	Moderate
Greater than 20% of the preschool age children below 0.70 µmol/l	Severe

Source: reference # 38

[1] ulcerations covering <1/3 of corneal surface

Retinol binding protein: Retinol is bound to retinol binding protein in the body, thus assessment of retinol binding protein is sometimes used as indirect assessment of serum retinol levels. Several Studies (39, 40) have recently shown that measurement of serum RBP correlates very closely with serum retinol levels.

Assessment of body reserves: In the past, there was considerable advocacy for the concept of relying upon the estimation of vitamin A concentration in the livers of patients at postmortem as a means of characterizing the vitamin A status of a population. In practice, this has proved difficult, except in the context of research. Furthermore, newer indirect and direct assessment methods have come to occupy the center stage. One of the frequently used techniques is relative dose-response technique (1).

Breast milk vitamin A concentration: It has long been known that the concentration of Vitamin A in the breast milk of undernourished mothers is low (1). The proposal to use this as an indicator of vitamin A status of a community is relatively new and needs to be tested under varying conditions. It has the advantages of being non-invasive, readily acceptable and the sample is easy to collect.

1.4.3. Assessment of dietary intake of vitamin A

Dietary assessment basically involves comparing the amount of vitamin A in foods consumed with the amount recommended and finding out the excess or deficit. Thus, it requires techniques of estimating the amount of foods consumed, the amounts of vitamin A contained in the foods and knowledge of the Recommended Daily Allowance (RDA). The amount of foods consumed is usually estimated by 24 hour recall method or on spot recording techniques. The amount of vitamin A contained in the foods consumed is estimated either by analyzing the contents or referring to food composition tables and RDAs are obtained from any standard nutrition books. Experiences regarding dietary assessment tend to indicate that dietary assessment is difficult, time- consuming, or poorly correlated with other indicators of vitamin A status. However, it is believed that well designed and carefully conducted dietary assessments can provide valuable information on the VAD status in the community.

In the other hand, dietary assessment techniques have some advantages. They are not invasive, expensive or complicated. Large numbers of subjects can be readily targeted and a profile of a population can be obtained without much difficulty. Knowledge of available and consumable sources of Vitamin A can be easily gained that are of extreme importance in subsequent dietary interventions. IVACG (41) introduced a simplified dietary assessment (SDA) as a method to identify and monitor groups at risk of suboptimal vitamin A intake.

1.4.4. Ecological and socioeconomic indicators

The WHO 1996 report of the consultative group introduced the concept of the use of "Ecological and related indicators associated with risk of VAD" (38). As shown in Tables 4 and 5, child feeding practices, nutritional status, prevalence of low birth weight, health status and food availability are some of the risk factors considered as ecological factors. The report also suggested considerations of socioeconomic indicators in the assessment of VAD such as maternal education levels, income and employment, water and sanitation conditions, access to health and social services, access to land, access to agricultural services and inputs.

It is emphasized, however, that the suggested cut off prevalence rates of ecological and socio-economic indicators are arbitrary and are recommended only to assist in the relative ranking of vulnerability levels of populations and therefore must not be used alone to replace biological indicators (those described above and specifically related to VAD) or to define whether a population is at risk.

Table 4: Ecologic indicators for assessing areas/population at risk of VAD (nutrition and diet-related indicators)

Indicators	**Suggested prevalence***
Brest-feeding pattern	
<6 months of age	<50% receiving breast milk
≤6-18 months of age	<75% receiving vitamin A containing foods in addition to breast milk,3 times/week
Nutrition status (<-2sd from WHO/NCHS reference for children <5 years of age)	
Stunting	≥30%
wasting	≥10%
Low birth weight (<2500g)	≥15%
Food availability	
Market	DGLV unavailable≥ 6 month /yr
Household	<75% household consume vitamin A-rich food at least 3 times/week
Dietary patterns	
6-71 month old children and Pregnant/lactating women	<75% consume vitamin A-rich foods at least 3 times/week
Semi-quantitative/qualitative Food frequency	Food of high vitamin A content eaten< 3 times/week by ≥75% vulnerable groups

Source: reference # 38

In other words, ecological and related indicators associated with risk of VAD are intended to be used as supportive evidence to the biological indicators, especially to biochemical indicators. They are also intended to be used as preliminary screening tools, in identifying areas for further conclusive assessments (38).

Table 5: Ecologic indicators for assessing areas/population at risk of VAD (Illness- related indicators in children 6-71 months of age)

Indicators	Suggested prevalence
Immunization coverage at 12-13 month age	< 50% Immunized or < 50% Immunized for Measles
Measles CFR	≥1%
Reported diarrhea (2 week period prevalence)	≥20%
Reported fever rates (2 week period prevalence)	≥20%
Helminthes infection rates .particularly ascaris	≥50%

Source: reference # 38

1.5. Global overview of magnitude and distribution of Vitamin A deficiency

Although vitamin A deficiency, particularly in the form of night blindness and xerophthalmia, was known long ago, the extent of the problem globally was documented only around 1960. In 1960, WHO sponsored a global survey and consultants visited 50 countries where VAD was suspected to have been a public health problem (42). The consultants confirmed the wide spread occurrence of VAD, especially in South and East Asia, Africa and Latin America.

In 1984/85, sixteen countries in Africa, five countries in Americas, six countries in Asia, three countries in East Mediterranean and four countries in Western Pacific, a total of thirty-four countries, were identified as being affected by VAD. In total, 41.9 million children were estimated to have been affected in these countries at that time (43). A number of surveys done in many countries since then have revealed that the number of countries affected by VAD has increased significantly. In Africa alone, the number of countries affected by VAD has risen to over thirty (44).

In 1994, the global estimate of clinically and subclinically affected under four children was about 2.8 million and about 251 million, respectively (1). The recent publication of the 5th world nutrition situation estimated that about 140 million under five children and more than 7 million pregnant women suffer from VAD every year and that 1.2 – 3 million children and significant number of women unnecessarily die each year (45).

1.6. Epidemiology of Vitamin A Deficiency in Ethiopia

1.6.1. Magnitude and distribution

The first evidence that highlighted the wide spread occurrence of VAD in Ethiopia came from the clinical examination of 7,000 pre-school and school-age children in 1957/58 in Gondar area, Northern Ethiopia (46). The survey indicated that 9% of the female and 2.2% of the male children had bitot's spots, while approximately 50% of the studied children had conjuctival xerosis.

Subsequent, fairly large study on nutritional status in several sites across the country, conducted in 1959 by the Inter-departmental Committee on Nutrition for National Defense (ICNND), confirmed that malnutrition in general and vitamin A deficiency in particular was common across the country. The study revealed that about 10% of pregnant women had vitamin A levels less than 10µg/100 ml (<0.7µmole/l) and 2% of male and 0.4% of female children had bitot's spot (47). Based on the recommendations of ICNND study, the Ethiopian Nutrition Institute (ENI) was established in 1962.

ENI undertook a national nutrition survey in 1980/81. The survey included 6636 preschool age children in 42 urban and semi-urban sites representing four agro-ecological zones. The survey indicated an overall bitot's spot rate of 1%, which was twice that of the cut-off point (0.5%) set by WHO, indicating a problem of public health significance (48). Based on this rate, about 6 to 8 million of the preschool age children in the country were estimated to have been at risk of vitamin A deficiency at the time. The prevalence of bitot's spot was found to have been higher among children in pastoral areas (1.6%), followed by the prevalence rates among those living in grain cropping (1.1%) and cash cropping areas (0.4%). There were no cases in Enset cropping zones. Among 742 children included in the biochemical study, 44% had deficient serum retinol levels. Parallel with the national survey, extensive review of out-patient medical records (188,737 records) over five years period done in the hospitals of Addis Ababa rendering ophthalmic and pediatric services revealed that 0.36% had various forms of vitamin A deficiency (49).

Another relatively recent study conducted by Guseppe De Solo in 1987 in Arsi and Bale regions in Southern Ethiopia showed that among 2647 preschool age children, the average prevalence rate of bitot's spot, corneal xerosis, keratomalacia/corneal ulceration were 5%, 0.8% and 0.05% respectively (50). In 1983, vitamin A deficiency assumed an epidemic level in Arsi Region where over 10% of the children had clinical manifestations. This rate could be considered as the highest prevalence rates ever recorded in Ethiopia (51). The then ENI promptly acted by universal distribution of vitamin A capsules across the Region. Similarly, in 1988, following the report of emerging eye problem in one of the villages in Harerge Region, Eastern Ethiopia, ENI conducted clinical and biochemical investigations (52). The results showed that among 240 children clinically examined, over a quarter were reported to have had night blindness and 5.6% to have had bitot's spot. Among the 76 children included in the biochemical study (subclinical VAD), 30.2% had deficient serum retinol levels (<0.35 μmole/l). The severity of exophthalmia observed in this area can also be considered as one of the serious conditions observed in the country.

In an attempt to investigate the relationship between vitamin A, iron and iodine status, a study that included 14,740 school children in Central Ethiopia was conducted in 1991 (53). The study revealed a bitot's spot prevalence rate of 0.91% which was close to two times the WHO cut-off point, indicative of public health significance.

With the aim of evaluating the EPI integrated vitamin A capsule supplementation program and the UNICEF's woreda integrated basic services (WIBS) approaches, baseline and end line surveys were conducted in SNNPR[2], Harari and Tigray regions in 1996. The baseline results indicated a bitot's spot prevalence rate of 0.2% and a prevalence of low retinol levels of 4.6% in SNNPR region (54, 55). The prevalence of bitot's spot and low serum levels in Harari Region were 7.8%, and 51.8% respectively, whereas the prevalence of bitot's spot and low serum levels in Tigray Region were 1.5%, and 16.2% respectively (55).

The end line results showed a slight reduction in the prevalence of VAD, although the magnitude was still in the public health significance levels. The post intervention prevalence rates were 0.5% bitot's spot and 6.8% low serum retinol levels in Tigray and 4.3% bitot's spot and 41.8% low serum retinol levels in Harari Region.

A study regarding vitamin A status of school children in Wukro, Northern Ethiopia showed that the prevalence of xerophthalmia was 5.8%; serum retinol levels were below 0.35 μmole/l among 8.4% school children and between 0.35 to 0.70 μmole/l among 51.1% of the children (56). The Report of National School Health and Nutrition Survey conducted by Save the Children USA in 2006 revealed that 8.2% of the studied primary school students had night blindness and 0.86% had signs of xerophthalmia (57).

1.6.2. Causes of vitamin A deficiency

[2] End line survey was not done in SNNPR

As mentioned earlier, vitamin A is essential for several metabolic activities in the human body, and therefore is regulated within narrow ranges in the circulating blood. When the dietary intake surpasses the requirement, the excess is stored in the liver and when the dietary intake falls below the requirement, the deficit is filled by mobilizing from liver stores. VAD ensues, only when vitamin A level in circulating blood falls below the requirement and liver store is inadequate to fill the deficit (1,2).

In most of the developing countries, factors contributing to inadequate consumption of vitamin A and sub-optimal utilization of the nutrient in the body are recognized as the primary causes of VAD. Several secondary factors, primarily emanating from less developed economies, poverty and ignorance, contribute to inadequate consumption and sub-optimal utilization of the nutrient in the body (1,2, 27).

Inadequate consumption is primarily the function of lack of access to vitamin A containing foods and a number of socio-demographic and cultural factors. Lack of access is due to inadequate own production of vitamin A rich foods, lack of income to purchase vitamin A rich foods and/or unavailability of vitamin A rich foods in the markets. The 1980/81 National Vitamin A survey attributed the high prevalence of VAD to the monotonous cereal-legume diet (injera and legume sauce) and lack of fruits and vegetables in cereal and cash cropping areas and to lack of vitamin A in the livestock products as the fodder is devoid of vitamin A in pastoral areas (48). Conversely, the study attributed the low levels of vitamin A deficiency in enset/root cropping zones to the relatively better availability and good practice of fruit and vegetable consumption in the area (48). The hypovitaminosis A in the village in Harerge area, was attributed primarily to the sole dependence of the community for some period of time on food aid devoid of vitamin A. The low levels of vitamin A in aid foods has been reported from other refugee camps in the country as well (58, 59).

Low blood retinol concentrations indicate depleted levels of vitamin A. This occurs with vitamin A deficiency, but also can result from an inadequate intake of protein, fat, oil and carbohydrates (60). It has also been established that malnutrition as a result of inadequate food consumption predisposes children to vitamin A deficiency (61). With the highest rates of malnutrition in Ethiopia, the parallel high rates of vitamin A deficiency is expected (62).

Iron deficiency can also affect vitamin A metabolism, as evidenced by the fact that iron supplements provided to iron-deficient individuals improved body stores of vitamin A and iron status (60). Studies have shown that iron deficiency anemia is common in Ethiopia, suggesting the fact that iron deficiency could also be one of the factors exacerbating vitamin A deficiency in the country (62). Severe zinc deficiency, which is also associated with strict dietary limitations, often accompanies vitamin A deficiency. As zinc is required to make retinol binding protein (RBP) which transports vitamin A, deficiency in zinc limits the body's ability to transport vitamin A stores from the liver to body tissues (60).

Socio-demographic and cultural determinants include an array of factors that impinge on precipitating vitamin A deficiency (such as sex, age, physiological status, education status, awareness regarding the importance of vitamin A and so forth). Evidence from several sources concurs that preschool age children, particularly children between 3-5 years of age are affected most (63, 64). A study has shown that VAD-related blindness is most prevalent in children less than 3 years of age (27). Among the preschool age children, children living at or below the poverty level; children with inadequate health care or immunizations; children living in areas with known nutritional deficiencies; recent immigrants or refugees from developing countries with high incidence of vitamin A deficiency or measles; and children with diseases of the pancreas, liver, intestines and children with inadequate fat digestion or absorption are more at risk to vitamin A deficiency (60).

It appears that consensus or conclusions have not yet been reached regarding the association of sex with VAD, although many studies tend to indicate that male children are more affected compared to female children (50, 65). One longitudinal study, however, reported lack of difference in the vulnerability of male and female children to vitamin A deficiency (66). The 1980/81 National vitamin A survey however, revealed that more male children were affected clinically, but were equally at risk to subclinical vitamin A deficiency (48).

There is no consistent, clear indication in humans, regarding gender differences in vitamin A requirements during childhood. Growth rates and presumably the need for vitamin A from birth to 10 years for boys are consistently higher than those for girls (67). In the context of varied cultural and community settings, however, variations in gender-specific child-feeding and care practices are likely to subsume a small gender differential in requirements to account for reported gender differences and prevalence of xerophthalmia.

Pregnant and lactating women constitute the other vulnerable group to vitamin A deficiency. Pregnant and lactating women require additional vitamin A, and as meeting the additional requirement is most often difficult in developing countries, they are more exposed to vitamin A deficiency (1, 68). Low level of maternal education and lack of awareness about the importance of vitamin A are usually ascribed as factors affecting vitamin A status of mothers and children (69, 70).

Food habits and taboos often restrict consumption of potentially good food sources of vitamin A (e.g., mangoes and green leafy vegetables). Culture-specific factors for feeding children, adolescents, and pregnant and lactating women (71-73) are common in Ethiopia. Illness, pregnancy and lactation related proscription and prohibitions of the use of specific foods exist in many traditional cultures (74).

Among factors contributing to the inefficient utilization of the nutrient in the body, disease is by far the most important determinant of VAD. Disease predisposes children to VAD by reducing the utilization of the vitamin A in the body (also by reducing dietary intake, as a result of reducing appetite). Studies have clearly shown that diarrheal diseases affect vitamin A status by substantially increasing the nutrient loss (75). Similarly, intestinal parasites (giardia, ascaris and hookworm), exacerbate vitamin A deficiency by reducing the absorption of the nutrient in the body (76).

VAD is most common in populations consuming most of their vitamin A needs from plant sources with minimal dietary fat (77). About 90 percent of ingested preformed vitamin A is absorbed, whereas the absorption efficiency of pro-vitamin A carotenoids varies widely depending on the type of plant source and the fat content of the accompanying meal (78).

In general, risk factors usually exert influence on vitamin A status in synergy. Fluctuations in the incidence of VAD throughout the year reflect the balance between intake and need. Periods of general food shortage (and specific shortages in vitamin A-rich foods), accompanied by peak incidence of common childhood infectious diseases (diarrhea, respiratory infections, and measles), and periodic seasonal growth spurts negatively affect the balance. Seasonal food availability can influence VAD prevalence by directly influencing access to pro-vitamin A sources (79).

1.6.3. Prevention and control efforts of vitamin A deficiency in Ethiopia

Since the awareness of the problem in 1959, a number of interventions aimed at preventing and controlling vitamin A deficiency have been implemented in the country. Strengthened IEC/BCC activities, along with attempts to promote the use and production of vitamin A rich foods including livestock products were in place in the sixties through eighties. Beginning from 1989, an attempt was made to reinforce the aforementioned efforts by supplementation of vitamin A via the available health infrastructures of the Federal Ministry of Health (FMoH). In most of the cases, the supplementation was disease targeted. Children who visited health institutions for the treatments of measles, diarrhea, malnutrition and related diseases were given supplements, according to the following schedule and dosage (80).

Table 6: Dosage and schedule for therapeutic supplementation

Target group	Immediately	Next day	2weeks later
Infant below 6 months	50,000IU	50,000IU	50,000IU
Infant 6-11 months	100,000IU	100,000IU	100,000IU
Children 12-59month	200,000IU	200,000IU	200,000IU

Source: reference # 80

In 1995, the Ministry of Health and UNICEF began implementing universal vitamin A supplementation through delivery of vitamin A capsules. All under-five children, lactating mothers and pregnant women were targeted to receive Vitamin A supplements (capsules) according to the recommended dosage and schedule through EPI and MCH contacts. However, evaluation of the EPI integrated vitamin A supplementation in Kambatta, Alaba, Timbaro Zone of SNNPR conducted in 1997 showed that the program was not implemented as it was anticipated. Lack of awareness at all levels of health care delivery system and inadequate resources were identified as major constraints (81).

Vitamin A supplementation plus non-health measures in sixty districts selected for Woreda Integrated Basic Services (WIBS) was initiated by UNICEF, in conjuncture with EPI integrated vitamin A supplementation. Non-health measures in the WIBS program included provision of horticultural seeds, strengthened IEC/BCC activities, treatments of childhood illnesses and delivery of Vitamin A capsules according to the following recommended dosage and schedule (80).

Table 7: Dosage and schedule for preventive supplementation

Target group	Dose	Frequency
Children 6-11months	100,000IU	Once
Children 12-59 months	200,000IU	Every 6 months
Postpartum women	100,000IU	Once, within one month of delivery

Source: reference # 80

Process and impact evaluation of the program was conducted in 1997 in Tigray and Harari regions. It was found that the coverage of vitamin A supplementation on the average has reached 87%. The study also revealed that the program has significantly reduced vitamin A deficiency, morbidity and malnutrition (55, 81, 82).

Beginning from 1997, the Ministry of Health resorted to bi-annual vitamin A capsule distribution through campaign either as a stand-alone activity or integrated with the National Immunization Days (NID). In 1997 and 1998, the coverage of vitamin A supplementation reached about 70%, but dropped to 30% in 2000 and 2001, as a result of the deaths of children due to choking that occurred during the supplementation (capsules accidentally falling in to the mouths of the children and blocking the air passage).

In June 2004, Enhanced Outreach Strategy (EOS) was initiated (83), where vitamin A supplementation was included as the main component of a package aimed at enhancing child survival by reducing child mortality and morbidity among children aged 6-59 months in food insecure woredas. The target of the program was 6.7 million children aged 6-59 months in 325 food insecure woredas (districts). Besides vitamin A supplementation, the package consisted of de-worming, nutritional screening and provision of food for malnourished children, social mobilization for routine immunization in general and immunization for measles in particular, IEC/BCC activities pertaining to child feeding, hygiene, malaria and HIV/AIDS. In 2005, except nutritional screening, other EOS activities were extended to all the districts in the country as an initiative referred as Extended Enhanced Outreach Strategy (EEOS). Thus, through EOS and EEOS, all children aged 6-59 months are targeted for vitamin A supplementation in the country.

2. RATIONAL OF THE THESIS

Several pocket level studies in the past and present have established that vitamin A deficiency is a major public health problem in Ethiopia. A nutrition profile developed by LINKAGES with the technical assistance from Food and Nutrition Technical Assistance (FANTA) indicated that 17% of child deaths in Ethiopia are associated with vitamin A deficiency (84). It is also evident that sizable proportion of children loose part or all of their sights as a result of vitamin A deficiency in Ethiopia.

Considering the immense impacts of vitamin A deficiency in terms of morbidity, mortality and disability, strengthened and concerted effort is needed to prevent and control VAD in Ethiopia. Such deliberations obviously require up to date, comprehensive and region specific information, on the magnitude, distribution and risk factors.

As shown in the literature review, most of the information regarding vitamin A, are generated through studies done in specific areas and specific groups of the population. While the information generated through specific and pocket level studies have been helpful in alerting planners and implementers, their use in planning at national and regional levels is limited. For planning, implementing and evaluating interventions aimed at controlling and preventing vitamin A deficiency at national level, up to date information on the magnitude of the problem is needed at country level. The national prevalence rate of vitamin A deficiency that has been quoted from1980/81survey is out dated (over 28 years old). In fact, the 980/81survey was not a national survey in strict sense, as only urban and semi-urban sites were included in the study. Therefore, it can be concluded that information on the magnitude at national level is lacking in Ethiopia.

With the adoption of the federal system, planning and implementing, health care service delivery and other responsibilities have fallen under the jurisdiction of the National Regional States. The role of the central/federal government has been limited to provision of technical support in terms of policy development and analysis as well as capacity building. Therefore, information at region level is imperative to enable regions to target, plan, implement and evaluate interventions regarding vitamin A deficiency. The literature review showed that information on magnitude of vitamin A deficiency at region level is not available.

The findings of the literature review regarding the information on the determinants of vitamin A deficiency at national and regional levels disaggregated by sex, age, residence etc, that are deemed important for designing targeted, specific, more effective and efficient interventions is limited. Even when such studies are available, they are usually speculative and inconclusive.

As the long-term and sustainable improvements on vitamin A status must ultimately rely on enhancing dietary consumption of vitamin A rich foods, accurate and disaggregate information on food/diet aspects, such as own production, market availability and consumption of vitamin A rich foods is crucial. However, as highlighted by the situation analysis, the diet/food aspect of vitamin A is not well addressed in Ethiopia. Particularly, the information on production, availability and consumption of fruits and vegetables that are the most important sources of vitamin A is limited.

Vitamin A contents of foods reported in the food composition tables were generated using open chromatography for extraction and spectrophotometer for quantification. Since then, HPLC techniques have been developed, where both extraction and quantification are performed simultaneously in the HPLC. Thus, validations have not been done using the latest specific and sensitive HPLC methods.

It is well established that pregnant and lactating women are vulnerable to vitamin A deficiency. The literature review showed that information regarding the situation of vitamin A deficiency among women such as magnitude, distribution and risk factors disaggregated by regions that are essential in designing interventions aimed at addressing maternal vitamin A deficiency, is scanty in Ethiopia. It is also most likely that school children particularly in the primary levels are also affected by the consequences of vitamin A, because they live in the same communities and share the same dietary practices. The literature review indicated that information concerning risk factors among school children is limited.

A number of interventions were put in place since the awareness of the existence of vitamin A deficiency in Ethiopia in 1957. Information on the impact of the interventions and the trend of vitamin A deficiency is, nevertheless, unavailable. In addition, a comprehensive national nutrition program is underway in Ethiopia and the information generated through this research is hoped to serve as baseline information on which the impact of the program on surmounting vitamin A deficiency could be evaluated.

In conclusion, the research is aimed at strengthening the ongoing deliberations to control and prevent vitamin A deficiency in Ethiopia by generating and availing the aforementioned relevant information that can be used by policy makers, planners and implementers in prioritizing, targeting, designing and evaluating vitamin A deficiency focused interventions.

3. OBJECTIVES OF THE STUDY

3.1. General objective

To assess and generate information on the magnitude and determinants of Vitamin A Deficiency that will be used for prioritization, planning, targeting and evaluation of programs aimed at preventing vitamin A deficiency in Ethiopia.

3.2. Specific objectives

- Map-out the magnitude and distribution of VAD in Ethiopia
- Assess the demographic, nutrition and health related determinants associated with subclinical VAD among preschool children in Ethiopia
- Assess the risk factors associated with clinical vitamin A deficiency among primary school students in Ethiopia
- Assess the availability and consumption practices of common vegetables and fruits in Ethiopia
- Determine vitamin A contents of common vegetables, fruits and some staple foods consumed in Ethiopia

4. Conceptual framework

The Conceptual Framework depicted in figure 3 below was adapted from the framework developed by UNICEF to guide the assessment of causes of malnutrition among under-five children (85). The aim of adopting and developing this framework is to better understand the mechanisms through which vitamin A deficiency manifests. Moreover, the framework is intended to guide the development of instruments, data collection, analysis and preparations of the manuscripts.

As shown in the framework, vitamin A status in developing countries is the outcome of actions and interactions of several immediate, underlying and basic factors. Among all factors, the low level of consumption of vitamin A containing foods is the major determinant, although it is not the only single determinant. It is well established that consumption of adequate amounts of foods rich in vitamin A, although it is a prerequisite, does not guarantee optimal vitamin A status. Factors that affect the utilization of the nutrient in the body are known to entail vitamin A deficiency even when adequate amount of the nutrient is consumed. For example, as absorption, digestion and circulation of vitamin A in the body require fats and protein, the presence/absence of these food items in the diet limit the amount of metabolically usable vitamin A in the body. Similarly, as discussed in the introduction section, the bio-availability of vitamin A in foods vary considerably across food types and influences vitamin A status. It is also well established that disease affects utilization of nutrients by compromising the absorption of nutrients or depleting the nutrients from the body. For example, it has been shown that diarrhea predisposes children to vitamin A deficiency by depleting the nutrient from the body.

As shown in the framework, food consumption is affected by a number of factors that can be aggregated under three major categories. Namely, factors related to access, factors related to socio-cultural domains and factors related to health.

Access refers to the opportunities and capacities of the households to obtain foods rich in vitamin A and vitamin A supplements. It covers issues related to own production of vitamin A rich foods, market availability of vitamin A rich foods, availability of income to purchase foods rich in vitamin A and seasonality of the vitamin A rich foods.

Socio-demographic and cultural factors include household, maternal and child related factors that are presumed to impact on vitamin A status, such as ethnicity, residence, socioeconomic status, age, sex, education levels, awareness levels about the importance of vitamin A and so forth. Health related factors cover the health related issues that affect the food consumption, such as low levels of food consumption as a result of reduced appetite. Some of the variables studied under this category include, types of illness, duration of illness, treatment status, vaccination status and others.

In the overall, the immediate and underlying causes of vitamin A status are determined by the economic-base such as resources, knowledge, environmental conditions, and the social, cultural and economic development levels.

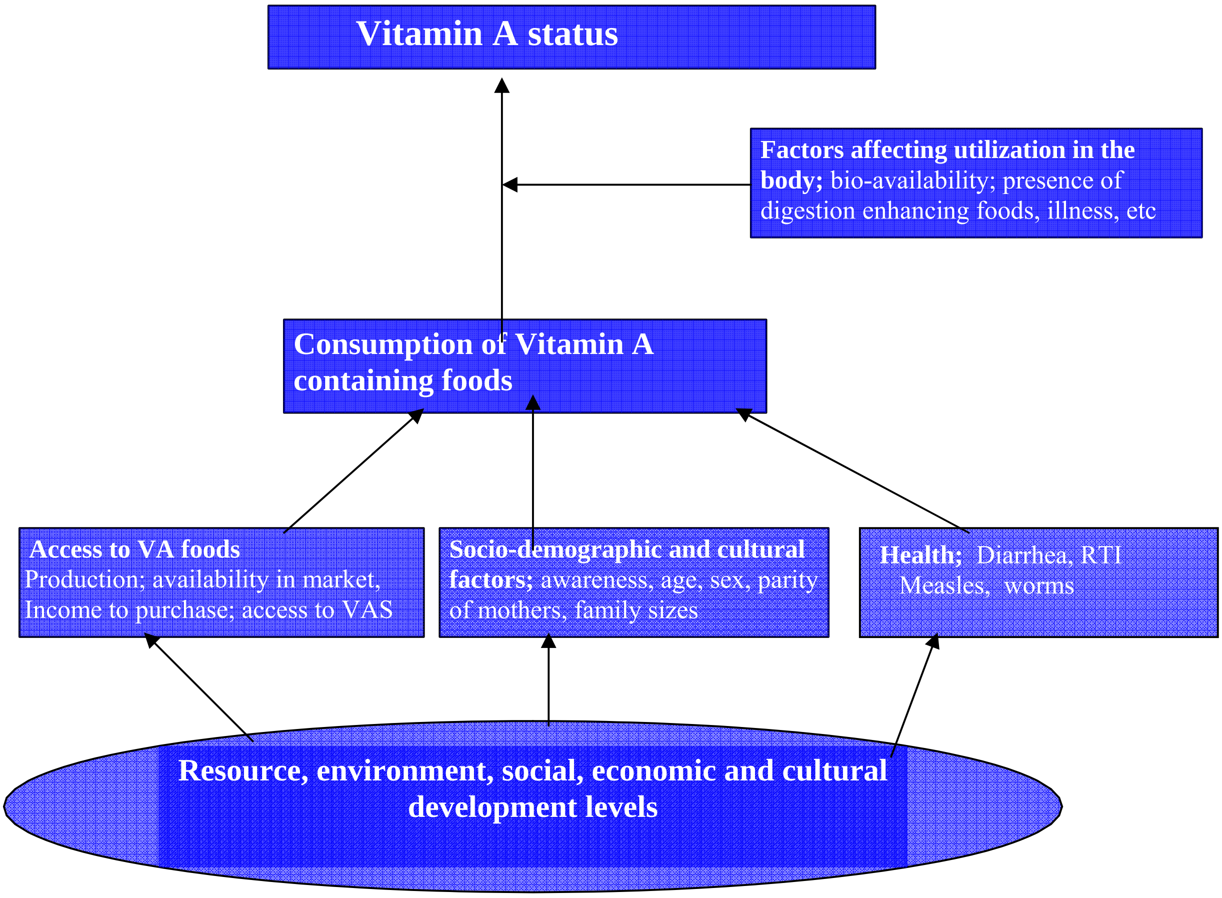
The research is aimed at examining most of the components depicted in the framework. Four manuscripts are prepared addressing four major thematic issues. Paper I, 'Magnitude and distribution of vitamin A deficiency in Ethiopia' examines the national and regional vitamin A deficiency prevalence rates based on both clinical and biochemical indicators (subclinical VAD).

Paper II, 'Demographic and health related risk factors to subclinical vitamin A deficiency among preschool children in Ethiopia' examines the associations of socio-demographic and health related factors to subclinical vitamin A deficiency among preschool age children.

Paper III, 'Risk factors associated with clinical vitamin A deficiency among primary school children in Arsi Zone, Ethiopia' examines the associations of socio-demographic and health related factors to clinical vitamin A deficiency among primary school children in Arsi Zone, Oromiya Region, Ethiopia.

Paper IV, 'Vitamin A contents, availability and consumption of fruits and vegetables in Ethiopia' examines factors related to access, consumption and vitamin A contents of vegetables and fruits commonly consumed in Ethiopia.

FIG. 3: Schematic Presentation of Factors Determining Vitamin A Status



Source: Adapted from the UNICEF framework on malnutrition

5. Methods

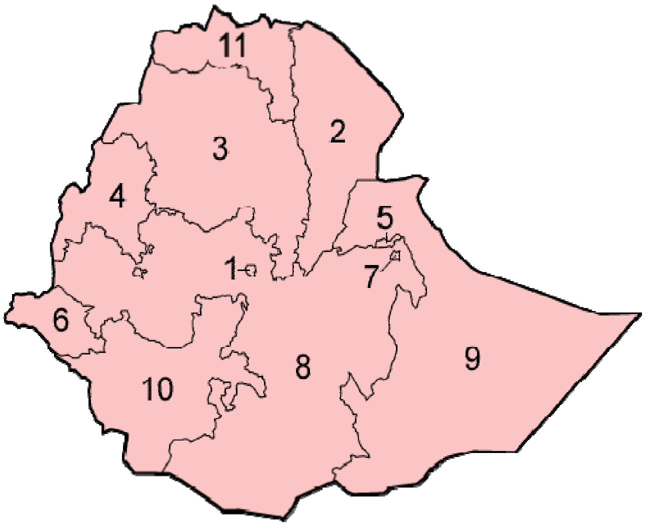
5.1. The Setting

Ethiopia is located in the Horn of Africa bordering Sudan in the West, Kenya in the South, Djibouti and Somalia in the East and Eritrea in the North. The country has an area of about 1.14 million square kilometers and exhibits immense geographical diversity, ranging from an altitude of 110 meters below sea level to 4,550 meters above sea level (62). In general, however, the topography of Ethiopia can be classified in to three broad ecological zones; namely, the "Kolla" or hot lowlands (approximately <1,500 meters above sea level), the "Weyna Dega" moderately warm midlands (between 1,500-2,500 meters above sea level), and "Dega" or cool temperate highlands (>2,500 meters above sea level).

Ethiopia's population has grown rapidly in recent years (at a rate of 2.6% per annum since 2000). According to the 2007 census, the population of Ethiopia at the time of the census was about 74 million (86). Children below 15 years of age make up about 45% of the total population, the age group 15 to 64 years constituted about 51.9% and elderly, aged >64 years, constituted about 3.2% (86).

The new Ethiopian Constitution, ratified in 1994 (87), introduced a Federal Government system. Nations and nationalities of Ethiopia instituted nine national regional states; namely, Tigray, Afar, Amhara, Oromiya, Somali, Benishangul-Gumuz, Southern Nations Nationalities and People's Region (SNNPR), Gambela and Harari (Fig.4). These nine national regional states along with two city Administrations, Addis Ababa and Dire Dawa, constitute the central/federal Government of Ethiopia.

Fig.4. Administrative regions of Ethiopia



1=Addis Ababa
2=Afar
3=Amhara;
4=Benishangul-Gumuz
5=Dire Dawa
6=Gambela
7=Harari
8=Oromiya
9=Somali
10=SNNPR
11=Tigray

The population sizes of the regions vary considerably. Oromiya Region (diversified agro-ecology and predominantly rural), which is also the largest region in terms of area, constitutes 34.4% of the total population, Amhara Region (predominantly highland and rural) constitutes about 25.4% and SNNPR (diversified agro-ecology, predominantly rural) constitutes about 19.9%. Thus, these three large regions make up approximately 80.0% of the total population of Ethiopia. Tigray (predominantly highland and rural), Somali (lowland and rural), Addis Ababa administration (predominantly highland and urban) and Afar (lowland and rural) constitute about 5.8%, 5.8%, 4.0% and 1.8% of the total population of Ethiopia, respectively. Dire Dawa City Administration, (lowland and urban), Benishangul-Gumuz (predominantly lowland and rural), Gambela (lowland and rural) and Harari regions (highland and predominantly urban) each represent less than 1% of the total population.

5.2. General Methodological Considerations

To address the objectives set, the research made use of information generated through three separate studies. The first study, the national vitamin A survey, addressed the magnitude and distribution of the problem (clinical and subclinical), factors contributing to vitamin A deficiency among preschool children and availability and consumption of fruit and vegetables. The second study addressed factors contributing to clinical vitamin A deficiency among primary school children in Arsi Zone (province) and the third study assessed the contents of vitamin A in commonly consumed staple foods, vegetables and fruits. Methodological provisions pertaining to each of the three studies are detailed separately in the following sections.

5.2.1. The National vitamin A survey

Study design and sample size considerations: The National Survey employed cross-sectional study design and multi-stage cluster sampling approach. As vitamin A deficiency is relatively rare disease, prospective and retrospective designs for the assessment of the magnitude and distribution at national or regional levels are not feasible, because both study designs would require huge sample sizes that entail almost insurmountable practical problems (27). Following-up of randomly selected children for certain period of time and identification of cases and controls across the country poses overwhelming technical and logistic challenges. Multistage, cluster sampling has been the most practical and popular means of sampling the population at risk to vitamin A deficiency at national or regional levels, because it enables the selection of small geographical and administrative units (clusters) in which all children, or a large proportion of them, are examined. Obviously, the larger the number of clusters, the more representative the sample will be. Nevertheless, the actual number of clusters to be included in a study is usually determined based on time, finance and logistic resources available at the disposal of the studies. As a guiding principle, however, it is recommended that the size of clusters must be limited to the number of children a team can examine in a day, which is roughly about 50 to 100 children per cluster depending on density of the population (27).

As discussed above, with the adoption of the federal system, the responsibilities of ensuring health care services to citizens have been relegated to regional national states. The shift in administrative modalities necessitated generation of data at regional levels. Therefore, sample size was determined in consideration of the need to avail results at regional and national levels. There are two sampling approaches to accommodate the intentions to present the information at region and nation level. The first one is to calculate sample size required for the smallest region and determine the sample sizes for other regions based on the proportion of the population of regions. The second option is to take equal sample sizes and weight the findings based on the population sizes of regions (27). The latter approach was adopted in this study, because sampling based on population sizes would have necessitated a huge sample sizes in the three big regions because the variations in population sizes between the smaller regions and bigger regions is enormous.

The number of children to be included in the clinical examination in each region was calculated using EPI INFO software (88). Based on the assumptions, p[3]=1%, confidence interval= 95%, error margin = ±0.5% and design effect = 2[4], a sample size of about 3000 was obtained for clinical examination in each region. As it was planned to collect blood samples from five percent of the children clinically examined (p[5]=44%, confidence interval= 95%, error margin = ±10.0% and design effect = 1.5) the anticipated number of children for the biochemical assessment was about 150 children per region. Again, as it was arbitrarily decided to interview 10% of

[3] P is the prevalence of clinical VAD, which was 1% in the national survey conducted in 1980/81

[4] Design effect of 1-2 is recommended to account for clustering effect (88). Design effect of 2 is used because clinical VAD is known to vary considerable across clusters

[5] P is the prevalence of subclnical VAD, which was 44% in the national survey conducted in 1980/81

mothers/caretakers of the children clinically examined, a total of about 300 households/caretakers were anticipated to be interviewed in each region.

Thus, the total number of children targeted nation-wide (9 regions were included in the study, 2 regions, Gambella and Somali were excluded due to security concerns at the time of the study) were 27000 for clinical assessment (bitot's spot, and night blindness), 1350 for biochemical assessment (serum retinol) and 2700 caretakers/households for the in depth interview. However, due to unprecedented problems that occurred during the survey, 86% response rate for clinical assessment, 88% response rate for biochemical assessment and 95% response rate for household interview were attained.

Sampling procedures: In each region, 30 peasant/urban dwellers associations (the smallest administrative units in Ethiopia) were selected randomly from a list of peasant/urban dwellers associations (primary sampling frame) available in regional head quarters. In each selected peasant/urban dwellers association one study village (cluster) was again selected randomly from the list of villages provided by kebele authorities (secondary sampling frame). The anticipated number of preschool age children in each cluster was 100 children (3000/30) for the clinical examination, 5 children (150/30) for biochemical assessment and 10 families (300/30) of the children clinically examined for interview on risk factors.

Selection of the children proceeded by first knowing sampling interval, that is by dividing the estimated number of children in the village by 100 (the number needed for clinical examination in each village) followed by identifying the center of the village and deciding on the direction through which the systematic sampling proceeds. Only households who had preschool age children were included in the study and when there were more than one eligible child in the household, only one randomly selected child was considered. The selected child and child's caretaker were given a temporary identifier/label and convened to temporary survey stations. In the stations, the children underwent clinical examination first and among them, blood was collected from every systematically selected 20th child and interviews were conducted with the families of every 10th child.

Survey tools: A separate form to fill the information related to clinical examination was prepared (annex 1). The form contained spaces for filling the findings related to basic demographic information, clinical signs and symptoms and morbidity.

A questionnaire addressing a wide range of information was prepared first in English and later translated to respective local languages. The household, maternal and child related risk factors, own production (backyard gardening), market availability and consumption practices of vitamin A rich foods were organized in specific sections (annex 2). Necessary materials such as vacutainers, disposable syringes, alcohol, ice box, cryovials and equipment for collection and maintenance of blood were prepared.

Data collection: MSc. Or PhD level supervisors were identified and assigned to each region first. Regions were requested to assign a medical doctor for the clinical examination and a senior laboratory technician for blood collection in their respective regions. Then, three days training workshop for supervisors, medical doctors and laboratory technicians was organized in Adama Town. The training workshop deliberated on standardization of data collection, technical issues and on the overall survey implementation procedures. Pilot study was done in Arsi Zone (province), about 125 km from Addis Ababa. Based on the lessons learned from the pilot survey, necessary modifications were made on the instruments. When it was agreed that common understanding on the overall conduct of the study among the participants has been reached, the teams (consisting of the supervisor, a medical doctor and laboratory technician) were dispatched to their respective assignment regions.

In the regions, the teams recruited six data collectors. The criteria of selection included; high school completion, experience in data collection and fluency in the local languages. Three days thorough theoretical and practical training was then given to the data collectors by the supervisors, medical doctors and laboratory technicians. Data collection commenced only when common understanding among data collectors was ascertained.

Supervisors were responsible for the overall implementation of the survey including administrative arrangements, selection of clusters and day to day supervision of the data collection. Physicians undertook the clinical examination, collected information on night blindness and morbidity. In the assessment of morbidity, either the diagnosis of health professionals when the child has visited health institutions or judgments from the signs and symptoms reported by the mothers/caregivers were used.

Laboratory technicians collected blood samples. All necessary safety measures were put in place during blood collection. Blood samples were kept in dark cool place until they were transported to health institutions where refrigerators were available. After centrifuging, the sera were kept in deep freezers below -80 Degree Celsius until the analyses were done. Analysis of serum retinol was done at the Ethiopian Health and Nutrition Research Institute using HPLC (89). Accuracy and precision of the analysis was monitored each day by repeated analysis of quality control reference material, SRM 968c obtained from National Institute of Standard and Technology, Gothenburg, USA. Values measured were 97.2±1.2% of the certified values for retinol. Within assay and between assays coefficients of variations were 3.9% and 14.2% respectively.

Data management: SPSS statistical software was used for the data entry, cleaning and data processing (90). Three experienced data entry clerks were employed for this purpose and thorough data cleaning/editing and processing was done following data entry. A child having unilateral or bilateral bitot's spot was considered as one case. In child night blindness and maternal night blindness analysis, those who reported having problems in daytime vision were excluded. Age of the children was categorized in to 6-24 months, 25-48 months and 49-71 months. The age of mothers was categorized as below 25 years, 25-35 years and above 35 years. Education level of mothers was categorized as 'can't read/write' and 'read/write or has gone to formal school'. The overall knowledge of mothers regarding vitamin A was categorized as 'knowing' or 'not knowing' at least one aspect of vitamin A, (consequences or foods rich or the importance). Similarly, overall illness was categorized as 'ill' (regardless of types, episode and severity of the illness) and 'not ill'.

Vegetable and fruit production (homestead gardening) refers to own production of a minimum of one vegetable and a minimum of one fruit at least once over the year preceding the survey. The availability of fruit and vegetable in the market refers to the awareness of the households about the availability of a minimum of one of the vegetables and fruits in their nearest markets at least once in the preceding year. The number of times the child has consumed vegetables or fruits over the week preceding the survey refers to the number of days the child has consumed any of the vegetables and fruits.

Results are presented for regions and for the country. National prevalence rates are weighted prevalence rates that are computed on the basis of proportions of the populations and the proportions of the samples.

Data analysis: Data analysis was done in SPSS statistical software (90), following intensive editing and data processing. In the analysis, frequencies, chi-squares and odds ratios are used. Bivariate analysis was employed to examine the unadjusted association of individual variables with vitamin A deficiency. Multiple Logistic Regression was used to determine the level of net/independent contributions of each risk factor to vitamin A deficiency by controlling the effects of other variables.

Data quality assurance: Supervisors checked questionnaires at the survey sites. Incorrect, unacceptable, doubtful responses were verified and redone the same day. Series of rules and ranges were used during data entry to identify incorrect responses or erroneous entry. Moreover, statistical procedures, such as, frequencies, ranges and plots were used to ascertain quality of the data.

5.2.2. The case control study

General: Prospective and cross-sectional studies are not usually employed to assess risk factors of a rare disease. Prospective studies require experimental or quasi-experimental designs where subjects or groups of subjects are assigned to exposure and non exposure groups and the incidence of disease in the groups are followed and relative risks are computed. Obviously, although prospective study design is superior, it however requires huge financial and logistic resources for the random assignments, provision of the exposure factor / placebo and follow-ups. Similarly, when the disease in question is rare cross-sectional studies require a huge sample sizes in order to get adequate cases to compare the exposure rates with that of the exposure rates among the 'not ill' groups. Clearly, this also entails huge financial and logistic inputs.

Case-control study design is more appropriate and commonly used to investigate risk factors associated with rare diseases. When clear criteria to delineate cases from controls are set, which is the main challenge in employing case-control studies, case-control studies provide reliable results with reasonable cost and logistics (91). Although causal relationships (relative risks) are not ascertained as a result of assessing exposure and diseases together (and after they have already occurred), case control studies provide odds ratios which are proxy indicators for relative risks. When the prevalence of a disease is very low, odds ratios more closely approximates relative risks. It is based on these facts that case-control study design was employed to explore risk factors associated with vitamin A deficiency among primary school students.

Site selection: Studies have consistently indicated that vitamin A deficiency is serious in Arsi Zone, Oromiya Region, Ethiopia (50, 51). For example, a prevalence of over 10% bitot's spot among preschool age children was recorded in 1993 that required mass treatment to mitigate the impact of the problem (51). With the assumption that school children also suffer from vitamin A deficiency, since school children also share everything with the preschool age children in a community, Arsi Zone was selected for the study.

Definition and recruitment of cases and controls: Cases were defined as school children in grades 3 and 4 who had confirmed clinical signs (bitot's spot's and corneal ulcerations) or confirmed night blindness. Controls were defined as students without any of the above mentioned conditions. The presence of clinical signs was confirmed and a student was considered as a case, only when the judgments of the ophthalmologist nurse and that of the senior nutritionist agreed. In the confirmation of night blindness, a number of questions related to the condition were asked. These include, whether the child knew what night blindness means, whether he/she bumps in to things at dusk, whether other children in the household have the same problem, whether he/she has difficulty in seeing at day time, whether he/she is forbidden to roam around in the house during dusk, whether he/she has been harassed or insulted as a result of bumping in to things at twilight. In addition, the frequency of consumption of fruits, vegetables and livestock products were also considered. Thus, night blindness was confirmed and the student was considered a case based on the synthesis of the responses of the student to these questions.

Sample size determination: For the purpose of estimating the sample size for the case control study, frequency of consumption of dark leafy vegetables, the proximate risk factor to vitamin A deficiency in rural Ethiopia, was considered. The recent results from the national survey suggest that about 38.1% did not at all eat vegetables, while 53% of children did not eat dark green vegetables adequately (three or more days in a week). A study has also shown that children who are not fed dark green leafy vegetables daily or every other day (three times or more in a week) were more than 2 times at risk of being affected by vitamin A deficiency compared to children who are fed at least every other day (77). These information were used to estimate the sample size required per group. Thus, using minimum expected OR = 2; proportion of children who did not consume adequately among controls =53%, confidence level = 95%; power = 80% and case-control ratio of 1:2[6], and applying the EPI-INFO 2000 formula (88), a sample size of 114 cases and 228 controls were obtained.

Implementation of the survey: A total of 3500 students in grade three and four in 20 primary schools in Arsi Zone were examined for clinical signs and questioned about the symptoms of night blindness. In total, ninety seven students were identified as having xerophtalmia (night blindness, 12(12.4%); bitot's spot, 71(73.2%); or both conditions, 14(14.3%)

[6] Increasing the number of controls improves the power of the study (91)

and for each of the 97 cases identified, two controls, without the clinical signs, matched by sex, age and grade were recruited. Due to various problems it became difficult to cover the 114 cases anticipated initially. The whole exercise required more time than planned stretching the financial and logistic requirements to the limit. The large number of schools that had to be visited and the long travel times to schools and difficulties to examine students as a result of the engagement of schools in other priorities stretched the time required. Retrospectively calculating the power of the study (based on number of cases (97), number of controls (194), prevalence rate of inadequate consumption of vegetables among controls (38.7%), Odds Ratio (4.1) and confidence level of 95% and case control ratio of 1:2, however, yielded over 90% power.

Senior ophthalmologist nurse undertook the clinical examination, collected information on night blindness and morbidity. In the assessment of morbidity, either the diagnosis of health professionals when the student has already visited health institution or judgments of the investigators based on the signs/symptoms reported by the students were used. Retrospective information on the potential risk factors was gathered using a structured questionnaire (annex 3). These included; demographic and socio-economic characteristics of the families of the students, type and frequency of consumption of vegetables, fruits and livestock products and knowledge regarding various aspects of vitamin A. The questionnaire was administered by five data collectors. The criteria of selection of data collectors included; high school completion, experience in data collection and fluency in local language. In order to standardize the data collection, three days thorough theoretical and practical training was given. Data collection commenced only when common understanding among data collectors was ascertained.

Data management and analysis: SPSS statistical software was used for the data entry, cleaning, data processing and analysis (90). An experienced data entry clerk was employed for this purpose and thorough data cleaning followed data entry. Age of the children was categorized as '8-10 years' and '11-15 years'. The overall knowledge of the students regarding vitamin A refers to 'knowing' or 'not knowing' at least one aspect of vitamin A, (consequences or foods rich or the importance). Similarly, overall illness refers to being ill regardless of types, episode and severity of the illness. In night blindness, those who reported having problems in daytime vision were excluded. The data entered and cleaned in SPSS was then converted to STATA version 7 and bivariate conditional logistic regression (to examine the association of each factor to the disease) and multivariate conditional logistic regression (to determine the level of independent contributions of presumed risk factors) were run. Only factors that showed significant associations in the bivariate analysis were entered in to the conditional logistic regression model.

Data quality assurance: The on-site data collection was consistently monitored and supervised by the principal investigator. In addition, the quality and the eligibility of the completed questionnaires were checked every night by supervisors. Incorrect, unacceptable, doubtful responses were verified next day. Series of rules and ranges were created and used during data entry to identify incorrect responses or incorrect entry. Moreover, statistical procedures, such as, frequencies, ranges and scatter-plots were used to ascertain quality.

5.2.3. Assessment of the contents of vitamin A in commonly consumed foods

General: Contents of nutrients in foods consumed in Ethiopia including vitamin A have been previously analyzed and reported in food composition tables (92, 93). The analysis of vitamin A in the food composition tables employed open chromatography for extraction and spectrophotometer for quantification. Since then, HPLC techniques have been developed, where both extraction and quantification are performed simultaneously in the HPLC. Thus, HPLC is a method of choice because of its high sensitivity and specificity and therefore HPLC techniques were used in the analysis of beta carotene content of foods.

Sample selection and collection: The information generated from the national VAD survey was used to identify the major staple foods, vegetables and fruits commonly consumed in the country. Thus, five common vegetables, five common fruits as well as five common staple foods were identified. Raw and cooked samples of these food items were randomly picked in duplicates, from the markets in Addis Ababa. Food samples were collected in polyethylene bags and were kept in refrigerators until analysis was done.

Analytical procedures: Vitamin A contents of foods were analyzed in duplicates according to Heinonen et al (94) method, the most extensively applied method. This method employs, homogenizing and extracting beta-carotenes by various reagents and quantifying the vitamin A content of the samples by comparing the retention time to the standard using HPLC. The analysis was done at the Ethiopian Nutrition Research Institute's laboratory

5.3. Ethical Considerations

The protocol developed for the implementation of the national survey on the magnitude and distribution of micronutrient deficiency had explicitly addressed all the ethical concerns pertaining to the study. The procedures were reviewed and approved by the implementing agency (EHNRI) and by the Research and Publications Committee of the Faculty of Medicine, Addis Ababa University.

The execution of the survey strictly adhered to what was stated in the protocol. Thorough explanations were first made to households regarding the aims of the study, the importance of their participation in improving the wellbeing of children and the precautions that will be taken during data collection. Moreover, respondents were informed that children who had xerophtalmia and other overt health problems will be treated and that incentives in the form of soap and biscuits will be given to the children. The fact that participation in the study is purely voluntary and that no repercussions would follow as a result of declining to participate in the study was also stressed.

Following such lengthy introductions and explanations, households were asked whether they are convinced and are willing to participate in the study. Households, who decided to participate, were then requested to sign in the consent form.

Only well-experienced senior laboratory technicians, who were working in regional laboratories, and who had ample experience in blood drawing using vacutainers systems collected blood samples. Utmost precautions were put in place to prevent any contaminations and infections following blood collection. Before the blood was taken, clearly visible vain was identified and the puncture spot was wiped with an alcohol prep swab and allowed to air-dry. Then the vain was punctured with sterile and non-reusable disposable syringes inserted to vacutainers. Once the blood was drawn, the syringes were disposed in to waste disposable baskets and were incinerated at the end.

Clinically identified xerophthalmic cases were treated at the spot (100,000 IU of vitamin A when the children are aged between 6-11 months and 200,000 IU of vitamin A when the children are aged between 12-71 months). Then households were given vitamin A capsules adequate to cover subsequent dosages and clarifications regarding the schedule were made. In addition, children who had trachoma were treated with tetracycline eye ointment. At the end of data collection, incentives in the forms of soap and biscuits were given for the children.

With regards to the case control study, the purpose of the study was explained in detail to the head teachers as well as the students and their cooperation was sought. Students were interviewed only when the head teachers and students agreed and signed the consent forms. In addition, all the cases were treated with 200,000 IU of vitamin A supplement at the spot, were given two capsules of 200,000 IU of vitamin A and were advised to take one capsule next day and the other after two weeks as recommended by WHO (80).

6. Results

6.1. Magnitude and Distribution of Vitamin A Deficiency

6.1.1. Clinical vitamin A deficiency

Nationally, almost equal number of female and male children participated in the clinical study (Table 8). Except in Benishangul-Gumuz and Addis Ababa where the proportion of male and female children was almost even, male children were slightly over represented in other regions. In terms of age, children below two years and children between two and four years were equally and more represented, compared to children aged four to six years. This is, however, expected as the lower age groups constitute the wider base of the population pyramid.

Table 8: Sex and age distribution of children included in the clinical survey by region, 2006, Ethiopia.

Region	N	Sex		Age		
		Male %	Female %	<24 months%	25-48 months %	49-72 months %
Afar	2327	47.9	52.1	40.7	32.5	26.8
Tigray	2883	52.0	48.0	46.2	38.9	14.9
Amhara	2681	51.8	48.2	34.2	41.6	24.2
Addis Ababa	2479	49.6	50.4	34.5	42.2	23.3
Oromiya	2497	51.8	48.2	34.2	40.6	25.2
SNNPR	2514	53.4	46.6	47.0	38.9	14.1
Benishangul-Gumuz	2653	49.3	50.7	40.6	38.7	20.7
Harari	2506	55.1	44.9	32.3	44.9	22.7
Dire Dawa	2420	53.6	46.4	40.2	36.0	23.9
Total	22960	51.6	48.4	39.0	39.4	21.7

The regional and national morbidity status of the preschool age children included in the clinical assessment is presented in Table 9. Nationally, 50.7% of the children were reported to have been sick two weeks prior to the survey. More than 60% of the children were sick in Afar, Amhara, and SNNP regions. A little over half of the children were sick in Tigray, Benishangul-Gumuz and Harari regions. Morbidity was relatively low in Addis Ababa, Dire Dawa and Oromiya.

Table 9. Sickness over the last two weeks prior to the survey by region, 2006, Ethiopia.

Region	N	Sick % (95% CI)
Amhara	2708	66.7(65.2-68.2)
Oromiya	2509	30.0(28.2-31.8)
Tigray	2902	52.3(50.5-54.1)
Addis Ababa	2508	34.9(33.0-36.8)
SNNPR	2544	61.9(60.0-63.8)
Benishangul-Gumuz	2671	55.0(53.1-56.9)
Dire Dawa	2444	32.3(30.4-34.2)
Harari	2528	56.2(54.2-58.2)
Afar	2334	65.3(63.3-67.3)
Total	23148	50.7(50.1-51.3)

The national weighted prevalence rate of bitot's spot was 1.7% (Table 10). The prevalence rate of bitot's spot was highest in the Amhara Region (3.2%) followed in Afar (2.1%), Oromiya (1.5%), Addis Ababa (1.4%), Harari (1.2%) and Dire Dawa (1.1%) regions. The prevalence rates were relatively lower in Benishangul-Gumuz (0.8%), Tigray (0.7%) and SNNPR (0.6%) regions. The national weighted prevalence rate of corrected child night blindness was 0.8% (Table 10). The prevalence rate of child night blindness was relatively higher in Harari (1.1%), Benishangul-Gumuz (1.0%), Amhara (1.0%), Tigray (0.9%) and Afar (0.9%) regions. The prevalence was low in Addis Ababa (0.5%) and Dire Dawa (0.3%).

The national weighted prevalence rate of maternal night blindness was 1.8% (Table 10) with the highest prevalence rate in Tigray Region (14.1%) followed by the prevalence rates in Benishangul-Gumuz (5.7%), Afar (1.2%) and Amhara (1.0%) regions. Again, the least prevalence was observed in Addis Ababa (0.4) and Dire Dawa (0.4%).

Table 10: Prevalence of clinical vitamin A deficiency by region, 2006, Ethiopia

Region	**Clinical VAD**			
	N	Bitot's spot %	Child XN* %	Maternal XN %
Afar	2334	2.1	0.9	1.2
Tigray	2902	0.7	0.9	14.1
Amhara	2708	3.2	1.0	1.0
Addis Ababa	2508	1.4	0.5	0.4
Oromiya	2509	1.5	0.5	0.9
SNNPR	2544	0.6	0.7	1.0
Benishangul-Gumuz	2671	0.8	1.0	5.7
Harari	2528	1.2	1.1	0.8
Dire Dawa	2444	1.1	0.3	0.4
Total	23148	1.7†	0.8†	1.8†

*XN = night blindness; † national prevalence rates are weighted averages

Analysis of the association of sex, age, residence and illness to clinical vitamin A deficiency is shown in Table 11. The prevalence of bitot's spot was significantly ($p<0.05$) higher among male than female children. The distribution of bitot's spot among the three age categories was also significantly different ($p<0.05$). The prevalence rate was found to increase with the increasing age and children in the age group 49-71 months were several times more at risk compared to the age groups 6-24 and 25-48 months.

The proportion of children with bitot's spot in predominantly rural areas (Amhara, SNNPR, Benishangul-Gumuz, Tigray, Oromiya and Afar) was significantly (p<0.05) higher compared to children in predominantly urban areas (Harari, Dire Dawa and Addis Ababa). Similarly, the prevalence of bitot's spot among those who reported to have been ill over two weeks prior to the survey was significantly (p<0.05) higher than those who were not ill.

Table 11: Prevalence of clinical VAD by sex, age, residence and sickness, 2006, Ethiopia.

Attribute	Category	N	Bitot's spot %	Significance*
Age	6-24	8945	0.6	**p<0.05**
	25-48	9055	1.6	
	49-72	4960	2.8	
Sex	Male	11848	1.8	**p<0.05**
	Female	11110	1.1	
Residence	Predominantly urban	7480	1.2	**p<0.05**
	Predominantly rural	15668	1.5	
Sickness	Yes	11729	1.6	**p<0.05**
	No	11419	1.2	

**based on chi square statistic*

6.1.2. Sub-clinical vitamin A deficiency

Sex and age distribution of children included in the subclinical study is shown in Table 12. In aggregate, almost equal number of male and female children participated in the subclinical study. More male children participated in Addis Ababa and Oromiya, whereas more female children participated in Dire Dawa and SNNPR regions. The proportion of children in the age groups <24 months was lowest compared with the proportion of children in age groups 25-48 months and 49-72 months. Significant variation from the national age distribution was observed in Afar Region, where the proportion of children below two years is significantly higher than the other two age groups.

Table 12: Sex and age distribution of children included in the subclinical survey by region, 2006,

Ethiopia

Region	N	Sex		Age		
		Male	Female	<24 months	25-48 months	49-72 months
Afar	82	50.0	50.0	46.3	29.3	24.4
Tigray	119	50.4	49.6	11.8	35.3	52.9
Amhara	90	47.8	52.2	3.3	36.7	60.0
Addis Ababa	98	63.3	36.7	22.4	51.0	26.5
Oromiya	108	60.2	39.8	8.3	38.9	52.8
SNNPR	115	44.3	55.7	17.4	46.1	36.5
Benishangul-Gumuz	114	47.4	52.6	14.9	48.2	36.8
Harari	136	39.7	52.3	14.0	51.5	34.6
Dire Dawa	100	35.0	65.0	8.0	37.0	55.0
Overall	962	48.3	51.7	15.6	42.2	42.2

The national weighted prevalence rate of subclinical vitamin A deficiency (serum retinol levels <0.7µmole/lt) was 37.7% with the 95% CI of 35.6%- 39.9% (Table 13). The high prevalence rates were observed in Afar (57.3%) and Oromiya (56.0%) regions followed in Dire Dawa (48.0%), Amhara (40.7%) and Harari (35.3%) regions. The lowest were recorded in SNNPR (11.3%) and Tigray (14.3%) regions.

Table 13: Prevalence of subclinical vitamin A deficiency by region, 2006, Ethiopia

Region	N	Serum retinol <0.7µmole/lt; % (95% CI*)
Afar	82	57.3(45.9-68.2)
Tigray	119	14.3 (8.5-21.9)
Amhara	91	40.7(30.5-51.5)
Addis Ababa	99	29.3(20.6-39.3)
Oromiya	109	56.0(46.1-65.5)
SNNPR	115	11.3(6.2-18.6)
Benishangul-Gumuz	115	27.8(19.9-37.0)
Harari	136	35.3(27.3-43.4)
Dire Dawa	100	48.0(37.9-58.2)
Total	996	37.7† (35.6-39.9)

† national prevalence rates are weighted averages; *CI=confidence interval

6.2. Risk factors for sub-clinical vitamin A deficiency among preschool children

The result of bivariate analysis is shown in the Table 14. The results indicated that there was no difference in the risk of subclinical vitamin A deficiency among rural and urban children. Children from Muslim households were found to be significantly more at risk to subclinical vitamin A deficiency (OR=2.63) compared to children form Christian households. Moreover, the results showed that children belonging to large-sized households (OR=1.33) and more under-five siblings (OR=1.44) were more at risk to vitamin A deficiency compared to children belonging to small-sized households (five and less) and a few under-five siblings (one or none).

The risk to vitamin A deficiency was significantly higher among children belonging to illiterate mothers (OR=1.42), children whose mothers had more deliveries (OR=1.49), and children belonging to mothers who had low levels of awareness about vitamin A (OR=1.95) compared to children belonging to literate mothers, children whose mothers had a few deliveries (two and below), and children belonging to mothers who had better awareness regarding vitamin A. There was no difference in the prevalence of subclinical vitamin A deficiency among children born to older, middle-age and younger mothers.

Table 14: Associations of household and maternal characteristics to subclinical VAD in Ethiopia, 2006.

Variable	Category	N	Deficient %	Unadjusted OR† (95% CI*)
Residence (N=966)	Urban	335	27.2	1
	Rural	631	24.7	**0.82 (0.62-1.08)**
Religion (N=949)	Christian	581	20.4	1
	Muslim	385	32.2	**2.63 (2.00-3.45)**
Household size (N=965)	Five and below	559	24.0	1
	Six and above	406	27.6	**1.33 (1.02-1.74)**
Under five size (N=966)	One or none	500	23.3	1
	Two and above	466	27.9	**1.44 (1.10-1.88)**
Literacy mother (N=966)	Literate	378	22.9	1
	Illiterate	588	27.2	**1.42 (1.08-1.87)**
Parity (N=957)	Two and below	407	22.6	1
	Three and above	559	27.6	**1.49 (1.13-1.96)**
Knowledge (N=960)	At least one fact	205	19.0	1
	Not at all	761	27.2	**1.95 (1.36-2.78)**
Age mother (N=960)	≤24 years	246	26.6	1
	25 to 35 years	587	25.2	**0.84 (0.76-1.21)**
	Above 35	127	25.3	**0.83 (0.75-1.17)**

*CI=confidence interval. †OR =Odds ratio

The results of bivariate analysis related to child characteristics showed that sex and age were not associated with subclinical vitamin A deficiency (Table 15). However, children who did not complete vaccination (OR=1.53), who did not receive vitamin A supplements at least once over the year (OR=1.57) and children who were ill fifteen days prior to the survey (OR=1.35) were significantly more at risk to subclinical vitamin A deficiency compared with their respective counterparts (Table 15).

Table 15: Associations of child characteristics to subclinical VAD in Ethiopia, 2006.

Variable	Category	N	Deficient %	Unadjusted OR† (95% CI*)
Sex N=962	Female	465	25.1	**1**
	Male	497	25.8	**1.06 (0.90- 1.38)**
Age N=960	24 months and below	192	25.3	**1**
	25 to 48 months	376	25.4	**0.96(0.76-1.23)**
	49 to 72 months	397	25.9	**1.03(0.86-1.23)**
Vaccination status (N=966)	Complete	498	22.9	**1**
	Not at all/incomplete	468	28.2	**1.53(1.17-2.00)**
VAS¶ last year	Received at least once	369	22.0	**1**
	Not at all received	597	27.6	**1.57(1.19-2.08**
Overall illness N=955	None	513	23.8	**1**
	At least one illness	453	27.5	**1.35(1.04-1.76)**

*CI=confidence interval; †OR =Odds ratio; ¶ Vitamin A supplementation

The results of multivariate logistic analysis are presented in Table 16. Among the child attributes (model I), not receiving vitamin A supplements at least once over the year (OR=1.45), illness over two weeks prior to the survey (OR=1.42), and incompletion of vaccination (OR=1.54) were significantly associated with high levels of subclinical vitamin A deficiency. Among the combined child and maternal variables (model II), the child attributes that were significant in model I, high parity levels (OR=1.46) and lack of awareness about vitamin A (OR=1.80) from the maternal attributes were significantly associated with high levels of subclinical vitamin A deficiency. While all the maternal and child-related attributes that were significant in Model II persisted to be significantly associated (model III), only religion was strongly and significantly (OR=2.23; 95% CI=1.63-3.06) associated with subclinical vitamin A deficiency from the household characteristics.

The likelihood ratio associated with the full model (model III) was 80.94 (p=0.000). Of this total likelihood ratio, child-related attributes (vitamin A supplementation, illness, and vaccination status) contributed only 19.39 (23.96%), maternal characteristics (parity, maternal awareness about vitamin A) contributed 26.58 (32.84%), and household characteristics (religion) contributed 34.98 (43.22%), indicating that, while maternal and child-related attributes constitute modest risks, religion constituted the single most important risk to subclinical vitamin A deficiency among children in Ethiopia.

Table 16: Risk factors contributing to vitamin A deficiency, 2006, Ethiopia.

Variables	Categories	n	**Model I** adjusted OR† (95% CI)	**Model II** adjusted OR† (95% CI)	**Model III** adjusted OR† (95% CI)
Religion	Christian	581	--	--	1
	Muslim	385			**2.23(1.63-3.06**)
Residence	Urban	335	--	--	1
	Rural	631			0.82(0.60- 1.14)
Family size	≤5 'small	559	--	--	1
	≥6 'large	406			1.08 (0.78-1.53)
# of <5 children	<2 children	500	--	--	1
	≥2 children	466			1.15(0.85-1.55)
Maternal age	≤24 years	246	--	1	1
	25-≤35 years	587		0.75(0.53-1.06)	0.80 (0.60-1.14)
	>35 years	127		0.60(0.36-1.18)	0.72 (0.43-1.22)
Maternal literacy	literate	378	--	1	1
	illiterate	588		1.10(0.81-1.50)	0.91(0.66-1.30)
Parity	≤2 births	407	--	1	1
	≥3	559		1.70(1.23-2.32)	**1.46(1.02-2.09)**
Knowledge about VA	At least one fact	205	--	1	1
	None	761		1.80(1.24-2.64)	**1.80(1.22-2.70**)
Age of the child	≤24 months	192	1	1	1
	25-≤48 months	376	1.05(0.72-1.53)	1.05(0.71-1.54)	1.12(0.76-1.66)
	≥49-71 months	397	1.07(0.73-1.55)	0.99(0.68-1.46)	1.13(0.76-1.68)
Sex	Female	465	1	1	1
	Male	497	1.10(0.84-1.44)	1.11(0.84-1.50)	1.10(0.83-1.46)
Vaccination status	Complete	498	1	1	1
	No/incomplete	468	1.74(1.30-2.35)	1.80(1.32-2.43)	**1.54(1.12-2.12)**
Illness	Not at all ill	513	1	1	1
	Ill at least once	453	1.40(1.06-1.83)	1.40(1.05-1.82)	**1.42 (1.07-1.90)**
VAS	Yes received	369	1	1	1
	Not received	597	1.43(1.10-1.99)	1.46(1.02-2.03)	**1.45(1.12-2.31)**
Model Likelihood ratio			19.39 (p=0.004)	45.94(p=0.000)	80.94(p=0.000)
Change in likelihood ratio				26.58(p=0.000)	34.98(p=0.000)

CI* = Confidence Interval

OR† = Odds Ratio

6.3. Risk factors for clinical vitamin A deficiency among school age children

As shown in Table 17, the age of the students enrolled in the study ranged from 8-15 years. Although insignificant, more students were enrolled from the age category of 8-10 years compared with 11-15 years. However, significantly more male students were enrolled in the study compared to female students (p<0.001). Similarly, significantly more rural students were included in the study compared to urban (p<0.001), while the difference in the enrollment from grades three and four was not that significant.

Table 17: Age, sex, grade and residence of the students enrolled in the case control study, Arsi Zone, Ethiopia, 2007.

Variable	Category	%	Significance*
Age	8-10 years	59.8	NS
(N=291)	11-15 years	40.2	
Sex	Male	60.8	p<0.001
(N=291)	Female	39.2	
Grade	3rd	59.8	NS
(N=291)	4th	40.2	
Residence	Town	14.4	p<0.001
(N=291)	Rural village	85.6	

**based on chi squared statistic; NS: Not significant*

Socio-demographic characteristics of the school students by VAD status is presented in Table 18. Significantly more households of the controls had functional radio compared to households of cases. More cases belong to Muslim families whereas more controls belonged to Christian households (P<0.001). The results of bivariate conditional logistic regression analysis indicated that the probability of the cases to have a functional radio and to belong to Christian households are 2.09 and 5.88 times less compared to that of the controls, respectively. There was no difference in roof types, household sizes, education of fathers and mothers between cases and controls.

Table 18: Socio-demographic characteristics of cases and controls in primary schools in Arsi Zone, Ethiopia, 2007.

Exposure variable	Categories	Cases (n=97) %	Control (n=194) %	Unadjusted OR* (95% CI†)
Radio ownership	Yes (reference)	74.2	85.1	
	No	25.8	14.9	**2.09 (1.11-3.93)**
Roof type	Corrugated iron (reference)	41.2	44.3	
	Grass-thatched	58.8	55.7	1.17 (0.67-2.03)
Religion	Christian (reference)	28.9	61.9	
	Muslim	71.1	38.1	**5.88 (3.01-11.78)**
Household size	Six and below (reference)	50.5	53.6	
	Seven and above	49.5	46.4	1.14 (0.69-1.87)
Education of the mother	Literate (reference)	29.9	37.1	
	Illiterate	70.1	62.9	1.85 (0.86-3.17)
Education of the father	Literate (reference)	52.6	59.3	
	Illiterate	47.4	40.7	1.39 (0.80-2.24)

* OR = Odds Ratio; †CI= Confidence Interval

Fifteen days morbidity status of the students is presented in Table 19. The proportion of children who reported to have been sick due to respiratory tract infections over the two weeks period prior to the survey was not that different among cases and controls. However, the proportion of students who reported to have had stomach problems, diarrhea and malaria plus other illnesses was significantly higher among cases compared with that of controls. The results of bivariate conditional logistic regression analysis indicated that the probability of the cases to have had diarrhea, stomach problems and at least one of the illnesses were 3.26, 2.20 and 2.71 times higher compared to that of the controls, respectively.

Table 19: Fifteen days morbidity status of students enrolled in the study, Arsi Zone, Ethiopia, 2007.

Variable	Category	Controls N =194 %	Cases N=97 %	Unadjusted OR* (95% CI†)
Respiratory tract infection	Yes	17.5	18.6	1.08 (0.55-2.14)
	No (reference)	82.5	81.4	
Diarrhea	Yes	5.7	15.5	**3.26 (1.38-6.80)**
	No (reference)	94.3	84.5	
Stomach problems	Yes	13.4	24.7	**2.20 (1.18-4.19)**
	No (reference)	86.6	75.3	
Malaria and others	Yes	4.6	10.3	2.97 (0.98-5.99)
	No (reference)	95.4	89.7	
At least one of the ailments	Yes	31.4	42.3	**2.71 (1.02-2.88)**
	No (reference)	68.6	57.7	

* OR = Odds Ratio; †CI= Confidence Interval

The proportion of the students who did not know any fact about the functions, consequences and foods rich in vitamin A was not different among cases and controls (Table 20). Most of the students knew that vitamin A is important for vision, that night blindness is the consequence and fruits and vegetables are the rich sources of vitamin A

Table 20: Knowledge of students regarding functions, consequences and foods rich in vitamin A, among primary school students in Arsi zone, Ethiopia, 2007.

Variable	Category	Cases N=97 %	Controls N=194 %	Unadjusted OR* (95% CI†)
Functions	None	64.9	61.9	1.36 (0.83-2.94)
	At least one	35.1	38.1	
Consequences	None	44.3	46.4	0.81 (0.37-1.77)
	At least one	55.7	53.6	
Foods rich in vitamin A	None	44.3	46.4	0.79 (0.35-1.80)
	At least one	55.7	53.6	
At least one fact about Vitamin A	None	35.1	38.1	0.85 (0.38-1.88)
	At least one	68.6	61.9	

* OR = Odds Ratio; †CI= Confidence Interval

The proportion of cases who reported to have consumed vegetables and fruits three or more times in the week preceding the survey was significantly lower compared with the proportions among the controls (Table 21). Similarly, the proportion of cases who have reported to have consumed animal foods at least once over the week was significantly lower than the proportion among the controls. The results of bivariate conditional logistic regression analysis indicated that the odds of cases in consuming inadequate vegetables, fruits and animal foods were 4.10, 2.42 and 2.72 times higher compared to that of the controls, respectively.

Table 21: Fruit, vegetable and animal food consumption among primary school students by VAD status in Arsi Zone, Ethiopia, 2007

Food category	Frequency of consumption over the week	Cases (n=97) %	Control (n=194) %	Unadjusted OR* (95% CI†)
Vegetable consumption	≤ 2 times	61.9	38.7	
	≥ 3 times (reference)	38.1	61.3	**4.10 (2.10-6.23)**
Fruit consumption	≤ 2 times	60.8	43.3	
	≥ 3 times (reference)	39.2	56.7	**2.42 (1.37-4.28)**
Animal food consumption	None	59.8	43.3	
	At least once (reference)	40.2	56.7	**2.72 (1.45-5.23)**

* OR = Odds Ratio; †CI= Confidence Interval

Multiple conditional logistic regression was run to identify the net contribution of potential risk factors (factors that showed significant variations between cases and controls in the bivariate analysis) to vitamin A deficiency among primary school children (Table 22). Among household characteristics, religion was found to be the strongest predictor of clinical vitamin A deficiency. Students from Muslim families were 7.03 times more at risk to vitamin A deficiency compared to students from Christian Families. Owning functional radio by the household was not associated with clinical vitamin A deficiency among primary school students. Among child characteristics, vegetable consumption was found to be the strongest predictor of clinical vitamin A deficiency. Students who did not consume vegetables adequately (three or more times) in the week preceding the survey were 3.04 times at odds of developing vitamin A deficiency compared with children who have consumed adequately. Illness in the two weeks preceding the survey was also found to be associated with vitamin A deficiency. Students who had at least one ailment over the two weeks prior to the survey were 2.04 times more at risk compared with children who were not ill. Animal food consumption and fruit consumption showed no association with clinical vitamin A deficiency among the students.

Table 22: Potential determinants of clinical vitamin A deficiency among primary school students, Arsi zone, Ethiopia, 2006.

Exposure variables	Categories	Adjusted OR (95% CI)
Household ownership of functional radio	Yes	1
	No	1.70 (0.77-3.52)
Religion	Christian	1
	Muslim	**7.03 (3.30-10.92)**
At least one illness 15days prior to the survey	No	1
	Yes	**2.04(1.07-3.69)**
Vegetable consumption	≥ three times over the week	1
	≤ two times over the week	**3.04(1.47-6.17)**
Fruit consumption	≥ three times over the week	1
	≤ two times over the week	1.82(0.89-2.64)
Animal food consumption	At least one over the week	1
	None over the week	2.09(0.99-3.64)

* OR = Odds Ratio; †CI= Confidence Interval

6.4. Availability and consumption of fruit, vegetable and animal foods

Characteristics of respondents who participated in the interview regarding availability and consumption of fruits and vegetables are presented in Table 23. In terms of religion, majority of the households were Muslim in Afar (98.8%), Dire Dawa (74.5%) and Harari (61.5%) regions. Majority of the households were Christians in Tigray (92.5%), SNNPR (89.8%), Amhara (89.1%) and Addis Ababa (79.7%) regions. The proportions of Muslim and Christian households were comparable in Oromiya and Benishangul-Gumuz regions.

As expected, the proportion of women who could not read or write was lowest in Addis Ababa (28.8%), followed in Oromiya (44.9%), Dire Dawa (44.4%) and Harari (51.6%) regions. The proportion of women who can not read or write was highest in Afar region (89.4%), followed in Amhara (77.5%) and Benishangul-Gumuz (69.3%) regions.

The knowledge of mothers regarding the functions of vitamin A was poor in general. Slightly over 94.0% in Afar, 94.0% in Amhara, 91.1% in Oromiya, 88.3% in Benishangul-Gumuz, 85.4% in Tigray and 81.1% in Addis Ababa, did not know a single aspect of vitamin A. It was slightly better in SNNPR (64.4%) and Harari (65.9%) regions.

Table 23: Religion, education and awareness of respondents included in the fruit/vegetable availability and consumption study by region, 2006, Ethiopia

Region	N	Religion		Can't read/write	Not known a single aspect of VA
		Christian %	Muslim %	%	%
Afar	254	1.2	98.8	89.4	94.2
Tigray	295	92.5	7.5	59.7	85.4
Amhara	267	89.1	10.9	77.5	94.0
Addis Ababa	354	79.7	28.2	28.8	88.1
Oromiya	236	56.4	43.6	44.9	91.1
SNNPR	284	89.8	10.2	67.6	64.4
Benishangul-Gumuz	300	53.3	46.7	69.3	88.3
Harari	287	38.3	61.7	51.6	65.9
Dire Dawa	275	25.5	74.5	44.4	69.8
Overall	2552	59.6	41.4	58.3	82.2

Proportion of households who did not produce/cultivate any of the common vegetables (kale, spinach, cabbage, carrot, tomato and pumpkin) over the year preceding the survey was 41.5% in the overall (Table 24). The proportion of households who did not produce any vegetable was highest in Addis Ababa (99.7%), followed in Afar (94.9%), Dire Dawa (94.2%), Tigray (86.4%) and Harari (63.1%) regions. Relatively, low proportions were recorded in SNNP (11.6%), Benishangul-Gumuz (25.3%) and Amhara (29.2%) regions. Production of common fruits over the year preceding the survey (mango, papaya, oranges, avocado and banana) indicated that 75.5% of studied households did not produce any of the fruits. The proportion was highest in Addis Ababa (100%), followed in Dire Dawa (95.3%), Afar (92.9%), Tigray (92.2%), Harari (83.3%) and Oromiya (81.8%) regions.

Table 24: Proportion of households who did not cultivate/produce any vegetable and any fruit over the year preceding the survey by region, 2006, Ethiopia.

Region	N	Vegetables % (95% CI*)	Fruits % (95% CI)
Afar	254	94.9(92.2-97.6)	92.9(91.1-94.7)
Tigray	295	86.4(82.5-90.3)	92.2(89.2-95.2)
Amhara	267	29.2(23.8-34.6)	75.3(70.2-80.2)
Addis Ababa	354	99.7	100
Oromiya	236	50.0(43.7-56.4)	81.8(76.9-86.7)
SNNPR	284	11.6(7.9-15.3)	55.3(49.5-61.1)
Benishangul-Gumuz	300	25.3(20.4-30.2)	55.0(49.4-60.6)
Harari	287	63.1(57.5-67.7	83.3(79.1-87.5)
Dire Dawa	275	94.2(91.4-97.0)	95.3(92.8-97.8)
Overall	2552	41.5† (39.7-43.7)	75.5† (77.2-73.8)

CI = Confidence Interval;* † *overall proportions are weighted proportions*

Awareness about availability of vegetables in nearby markets over the year preceding the survey (kale, spinach, cabbage, carrot, tomato and pumpkin) indicated that high proportion of households in Afar Region (82.3%) did not see any of the vegetables mentioned in the nearby markets (Table 25). Relatively few households in Harari (20.9) and Tigray (15.6%) regions have reported similarly. Otherwise, most households in all regions reported that vegetables were available in the markets. Most households in Afar (79.5%) and in Tigray (67.5%) regions reported that they have not seen any of the fruits (mango, papaya, oranges, avocado and banana) in the near by markets over the year. The proportion of households who had similar responses was moderately high in Amhara (18.0%), Oromiya (14.8%), Harari (13.9%) and Dire

Dawa (11.3%).

Table 25. Proportion of households who did not see any of the common vegetables and fruits in nearby markets over the year preceding the survey, by region, 2006, Ethiopia

Region	N	Vegetables % (95% CI*)	Fruits % (95% CI)
Afar	254	82.3	79.5
Tigray	295	15.6	67.5
Amhara	267	3.4	18.0
Addis Ababa	354	0.8	0.8
Oromiya	236	2.1	14.8
SNNPR	284	8.1	10.6
Benishangul-Gumuz	300	1.7	7.3
Harari	287	20.9	13.9
Dire Dawa	275	11.3	11.3
Overall	2552	15.4†	24.0†

**CI = Confidence Interval; † overall proportions are weighted proportions*

In aggregate, 38.1% of the children did not eat any of the vegetables (kale, spinach, cabbage, carrot, tomato and pumpkin) over the week preceding the survey (Table 26). The proportion of index children who did not consume any vegetable was high in Afar (85.0%), Tigray (77.6%), Amhara (61.8%) and Addis Ababa (59.3%) and was relatively low in SNNPR (7.0%), Dire Dawa (15.6%) and Oromiya (18.6%). In aggregate, 36.5% did not eat any of the fruits (mango, papaya, oranges, avocado and banana) over the week preceding the survey. The proportion of index children who did not consume fruits was high in Tigray (88.1%) and Afar (83.5%) regions.

Table 26: Proportion of children who did not consume any of the common vegetables and fruits over the week preceding the survey by region, 2006, Ethiopia.

Region	N	Vegetables % (95% CI*)	Fruits % (95% CI)
Afar	254	85.0(80.6-81.6)	83.5(78.8-88.1)
Tigray	295	77.6(72.8-82.4)	88.1(84.4-92.8)
Amhara	267	61.8(56.0-67.6)	30.3(24.8-35.8)
Addis Ababa	354	59.3(54.2-64.4)	33.9(29.0-38.0)
Oromiya	236	18.6(13.5-23.7)	28.0(22.3-33.7)
SNNPR	284	7.0(4.0-10.0)	35.2(29.7-40.7)
Benishangul-Gumuz	300	58.3(52.7-63.9)	41.3(35.7-46.9)
Harari	287	35.5(30.0-41.0)	23.3(14.9-32.2)
Dire Dawa	275	15.6(11.3-19.9)	31.6(26.1-37.1)
Overall	2552	38.1† (36.2-40.0)	36.5† (34.6-38.4)

**CI = Confidence Interval; † overall proportions are weighted proportions*

Over 66% of the children included in the study did not eat meat over the week preceding the survey (Table 27). Proportion of index children who did not eat meat over the week preceding the survey was highest in SNNPR (96.5%), followed in Tigray (89.2%) and Afar (84.6%) regions. Close to 53% of the children included in the study did not eat eggs even at least once over the week preceding the survey. The proportion of index children who did not consume egg was high in Afar (84.3%), Tigray (81.0%) and Benishangul-Gumuz (64.7%) regions. The proportion was lowest in Oromiya Region (23.3%). In the overall, 33.4% of the households did not use oil in the week preceding the survey. The proportion of households who did not use oil was high in SNNPR (67.6%), Benishangul-Gumuz (50.0%) and Oromiya (38.6%) regions, whereas it was low in Harari (13.1%), Addis Ababa (14.1%) and Dire Dawa (16.4%).

Table 27: Proportion of children who did not consume any meat, egg and oil over the week preceding the survey by region, 2006, Ethiopia.

Region	N	Meat % (95% CI*)	Egg % (95% CI)	Oil % (95% CI)
Afar	254	84.6 (80.2-89.0)	84.3(79.8- 88.8)	30.7(25.0-36.4)
Tigray	295	89.2(85.6-92.8)	81.0(76.5-85.5)	31.2(25.9-36.5)
Amhara	267	60.7(54.9-66.5)	49.4(43.4-55.4)	21.0(16.1-25.9)
AA	354	57.1(52.0-62.2)	39.5(34.4-44.6)	14.1(10.5-17.7)
Oromiya	236	53.8(47.4-60.2)	23.3(17.9-28.7)	38.6(32.4-44.8)
SNNPR	284	96.5(94.4-98.6)	56.2(50.2-61.8)	67.6(62.2-73.0)
Benishangul -Gumuz	300	63.3(57.9-68.7)	64.7(59.3-70.1)	50.0(44.4-55.6)
Harari	287	61.3(55.7-66.9)	33.1(27.7-38.5)	13.1(11.1-15.1)
Dire Dawa	275	32.0(26.5-37.5)	39.3(33.5-45.1)	16.4(12.0-20.8)
Overall	2552	66.6† (64.7-68.5)	52.5† (50.5-54.5)	33.4† (28.2-31.8)

**CI = Confidence Interval; † overall proportions are weighted proportions*

Comparative analysis of the situation regarding production and market availability of fruits and vegetables as well as consumption of fruits, vegetables, meat, egg and oil between predominantly urban areas (Dire Dawa, Addis Ababa and Harari) and predominantly rural areas (Amhara, SNNPR, Benishangul-Gumuz, Tigray, Oromiya and Afar) is shown in Table 28. Significantly more rural households have reported to have produced/cultivated vegetable and fruits (P<0.001) compared to urban households. In the contrary, significantly more urban households (P<0.001) have reported that vegetable and fruits were available in the markets compared to rural households. The proportion of index children who consumed vegetables in the week prior to the survey was not different between the groups. However, the proportion of the index children who have consumed fruits, meat, eggs and oil was significantly higher among the urban dwellers (P<0.001) compared to the rural dwellers.

Table 28: Production, availability and consumption of common fruits, vegetables, meat, eggs and oil by residence, 2006, Ethiopia

Attribute	Response	Predominantly urban (n=916) %	Predominantly rural (n=1630) %	Significance
Vegetable production	No	86.6	49.1	P<0.001
	Yes	13.4	50.9	
Fruit production	No	93.3	75.1	P<0.001
	Yes	6.7	24.9	
Vegetable availability	No	10.3	18.2	P<0.001
	Yes	89.7	81.8	
Fruit availability	No	8.1	33.0	P<0.001
	Yes	91.9	67.0	
Vegetable consumption	No	39.0	38.0	NS
	Yes	61.0	62.0	
Fruit consumption	No	30.0	40.1	P<0.001
	Yes	70.0	59.9	
Meat consumption	No	51.0	75.5	P<0.001
	Yes	49.0	24.5	
Egg consumption	No	37.4	61.0	P<0.001
	Yes	62.6	39.0	
Oil consumption	No	11.4	40.4	P<0.001
	Yes	88.6	59.6	

based on chi squared statistic; NS=Not Significant

6.5. Vitamin A contents of major food items consumed in Ethiopia

The result of the beta carotene analysis of common vegetables and fruits consumed in Ethiopia is depicted in Table 29. Uncooked kale and raw carrots contain the highest amount of beta-carotene. Although underestimated, higher beta carotene content of uncooked kale and raw carrots were also reported in the Ethiopian Food Composition Table. In this analysis, spinach, mango and papaw were found to contain relatively high amounts of beta-carotene, while very low amounts were reported in the Ethiopian Food Composition Table. Modest amounts of beta carotene contents in tomatoes and pumpkin as well as small amounts in cabbage, orange and banana were observed in this analysis and in the Ethiopian Food Composition Table.

Table 29: Beta carotene contents of the common vegetables and fruits consumed in Ethiopia, 2006.

S/N	Sample Type	Amount (µg/100gm) (average of two samples)	Amount in Ethiopian Food Composition Table (µg/100gm)
1	Kale (raw)	6100.45	2330
2	Kale (cooked)	4400.08	11.25
3	Carrot (raw)	5800.09	4780
4	Carrot (cooked)	4300.30	1.15
5	Spinach (Raw)	800.12	3.06
6	Spinach (cooked)	500.18	2.19
7	Cabbage (raw)	46.97	0.09
8	Cabbage (cooked)	12.47	0.04
9	Orange	65.69	0.8
10	Banana	58.72	B.D.L*
11	Mango	500.54	B.D.L
12	Avocado	B.D.L	B.D.L
13	Pawpaw	800.86	0.04
14	Tomato (raw)	200.29	620
15	Pumpkin (raw)	200.63	280

*B.D.L = Below Detectable Levels

The result of the analysis of beta carotene content of common foods consumed in Ethiopia is depicted in Table 30. The beta-carotene content of injera, (a pancake type of bread made mainly from a cereal known as teff) one of the most common foods consumed in Ethiopia, is below detectable levels, while the contents of the shiro wot, a sauce of pea/beans commonly consumed with injera is moderate. The relatively high levels of beta carotene in shiro wot compared to the shiro flour (flour of pea) is due to the ingredients such as pepper, carrots and tomatoes, added to it during cooking. The content in bread, kocho (bread of a root crop known as 'Enset') and potato which are also commonly consumed in Ethiopia is negligible.

Table 30: Beta carotene contents of some staple foods consumed in Ethiopia, 2006.

S/N	Sample Type	Amount (µg/100gm) (average of two samples)	Amount in Ethiopian Food Composition Table (µg/100gm)
1	Injera	B.D.L*	B.D.L
2	Teff flour	B.D.L	B.D.L
3	Shiro wot	600.21	684
4	Shiro flour	100.60	Trace[1]
5	Wheat flour	27.17	0.16
6	Bread	5.98	0.09
7	Potato (raw)	4.67	B.D.L
8	Potato (boiled)	B.D.L	B.D.L
9	Kocho (Raw)	B.D.L	B.D.L
10	Kocho (cooked	B.D.L	B.D.L

* B.D.L = Below Detectable Levels; [1]Trace = some beta carotene activity

7. Discussion

Initially, only clinical signs and symptoms associated with vitamin A deficiency, namely, night blindness; bitot's spot and corneal lesions, which are manifestations of severe forms of vitamin A deficiency, were used as indicators of the magnitude of the problem in a community/population. When it became clear that milder and moderate vitamin A deficiency at subclinical level was associated with significant increase in child mortality and morbidity in the 1980s, interest in subclinical vitamin A deficiency arose and techniques in the assessment began to emerge (1). The fact that clinical signs and symptoms are the tip of the iceberg, occurring after substantial damages to internal tissues had already been inflicted, justified the importance of the assessment of subclinical vitamin A status. Subclinical assessment provides opportunities to prevent the problem at its early stages. In addition, the consultative group convened by WHO in 1996 also recommended the use of ecological (health, nutrition, food availability, diet) and socio-economic related risk factors in the preliminary assessment of vitamin A status of the community/population (38).

As VAD indicators (clinical, subclinical, ecological and socioeconomic) address different aspects of the problem as well as different stages in the progression of vitamin A deficiency, the 1966 WHO consultative group forwarded recommendations on appropriateness and relevance of these indicators for various VAD surveillance activities (38). In the report, surveillance was described as 'the continued oversight of a disease and encompasses activities such as determining the magnitude, severity and distribution, identifying and characterizing high risk areas and populations, tracking changes/trends and evaluating the impacts of programs'.

The WHO's consultative group recommended that clinical signs and symptoms are more appropriate in the assessment of the magnitude of the problem and public health significance should be warranted when the prevalence of any one of the clinical vitamin A deficiency (bitot's spot, corneal ulcerations and corneal scar) indicators is below its recommended cut off points.

Regarding subclinical indicators, however, the consultative committee suggested that subclinical indicators are more useful in identifying areas/populations at risk, assessing trend and evaluation of programs. When used for assessing the magnitude of the problem, WHO recommends that public health significance should be concluded when two or more subclinical indicators (serum retinol, retinol binding protein, breast milk serum, relative dose response etc) are below their respective cut off points or when one subclinical indicator and at least four ecological and/or socioeconomic indicators are below their respective cut-off points (38). This recommendation is based on the fact that biochemical indicators are influenced by several non vitamin A deficiency related causes and can not individually indicate vitamin A status of the community substantively. For example, serum retinol is in strict homeostasis and can not indicate the overall vitamin A status in the body until the liver stores are completely depleted, which is the latest stage in the progression of the deficiency (1). Again, biochemical indicators are influenced and affected by infection. During infection, protein carriers of serum retinol are depleted showing low levels of serum retinol, without actual vitamin A deficiency (1). Thus, serum retinol levels (biochemical indicators) alone are not good indicators for diagnosis and determining the magnitude of the problem, but the frequency distributions of serum retinol levels provide useful information for identifying areas/populations at risk, assessing trend, evaluation of programs and in substantiating the results of other indicators (38).

As emphasized elsewhere, socioeconomic, ecological and related indicators associated with risk of VAD provide supportive evidence to the biological indicators (clinical and subclinical indicators). In addition, ecological and related indicators are recommended to be used in rapid assessments and preliminary screening of areas and populations for further in depth assessments or prioritizing interventions (38).

In this study, child and maternal night blindness, bitot's spot and serum retinol levels were used to assess the magnitude and distribution of vitamin A deficiency. Moreover, the situation regarding potential risk factors such as morbidity, awareness about vitamin A, own production and market availabilities of fruits and vegetables as well as other socioeconomic and ecologic conditions were also assessed.

As detailed in the introduction section, the prevalence of night blindness is considered as one of the indicators in assessing VAD status in a population. WHO recommends a prevalence of 1% of night blindness among preschool children as indicative of public health concern. The information on night blindness depends on observations and reports of mothers and therefore, it is most often underestimated, especially in areas where local terms to describe it are unavailable. Because of fear of being hurt, children may not roam during dusk and even when they roam and bump in to things, mothers may not notice it, especially in areas where the problem is uncommon (38). Thus, although, the weighted national prevalence of child night blindness is close to the WHO recommended levels, it should be noted that the actual prevalence rate of child night blindness could be higher than what was observed in this study. The observed prevalence is significantly lower compared to 28.8% prevalence rate reported in one of the villages in Harerge Region (52). The prevalence rates in Harari, Amhara and Benishangul-Gumuz are just at the cut-off points or slightly above and must constitute some concern.

Due to their increased vitamin A demands and the difficulty to meet the extra need, mothers are prone to vitamin A deficiency (1,38). The weighted national prevalence of maternal night blindness is nearly two times higher than the WHO cut-off points. The probable absence of maternal supplementation while there was a good coverage of VAS among the preschool age children in Tigray region may explain the enigma regarding the observed high prevalence rate of maternal night blindness and the relatively low prevalence rates of child night blindness in the region.

As mentioned above, the prevalence of bitot's spot (along with other supportive indicators when available) was recommended by WHO to be used as an indicator of the magnitude of vitamin A deficiency in a population (38). WHO has recommended a cut-off point of 0.5% as indicative of public health significance in a community/population (27). The practical implication of setting the cut off point is to bring the issue in to the attention of planners and implementers so that interventions are initiated or strengthened when the prevalence rate exceeds the cut off points. The weighted national prevalence rate of bitot's spot, (1.7%) observed in this study is more than three times higher than the WHO cut-off points. Based on these findings and substantiated with the serum retinol results, Ethiopia can be considered as one of the countries where VAD is a major nutritional problem at the time of the survey. Currently, it is more likely that the situation may have improved, since VAS through EOS has been intensively implemented in the years following the survey. However, this can not be taken for grant, unless it is supported by credible coverage surveys as well as sound impact evaluation studies.

Earlier studies have demonstrated that the prevalence of vitamin A deficiency (prevalence of bitot's spot) is high and widely distributed in the country. One of the earliest studies, carried out in 1957 (47), revealed an average bitot's spot prevalence rate of 1.5%, which is comparable to the bitot's spot rate of 1.7% found in this study. The 1980/81, national study (48), showed a bitot's prevalence rate of 1.0% with rates as high as 1.6% in the pastoral zone and no cases in the Enset zone. Compared to the 1% prevalence rate of bitot's spot reported in 1980/81 study, it is readily evident that the prevalence rate has increased by nearly 0.7 percentage points in 2006. The recurrent drought, chronic food insecurity and population explosions may at least partially explain the increasing trend in the prevalence of vitamin A deficiency in Ethiopia. The results also signify the fact that the impact of several interventions put in place since the awareness of the problem in the sixties has not been sufficient to reverse the trend.

Among the regions, the highest prevalence rate of bitot's spot was recorded in Amhara and Afar regions whereas the lowest prevalence rates were observed in Tigray and SNNPR. Since, the 1980/81 study did not disaggregate the results by regions (48), direct comparisons (to see the trend) in regional prevalence rates are difficult. Nevertheless, it appears that some insight can be gained by comparing the cereal cropping zone result of the 1980/81 against the results observed in Amhara and Tigray Regions (Amhara and Tigray Regions belong to cereal cropping zone), pastoral zone results of the 1980/81 against the results in Afar Region (Afar is pastoral region) and Enset cropping zone results against the results in SNNPR (SNNPR region mostly belongs to Enset cropping zone).

Compared to the 1980/81 findings, prevalence rate of bitot's spot has increased in the Amhara Region. The observed high prevalence of morbidity, poor consumption of fruits and vegetables and the monotonous 'injera-shiro' diet can be considered as the likely factors that might have exacerbated VAD in the Amhara Region. The study by De Sole et al. (50), suggested that the higher prevalence of vitamin A deficiency in the cropping zone can be attributed to the mono-crop culture and monotonous diet. Tigray Region is one of the regions where reduction in the prevalence of bitot's spot among preschool children was observed. Previous studies indicated high levels of VAD in the Region (55, 82). Although, it is not supported by proper statistical tests, the low prevalence rates observed in Tigray Region is attributable to several inputs, most probably to the high VAS coverage.

Compared to the pastoral zone results of 1980/81, the prevalence of bitot's spot has increased in Afar Region. Multiple factors such as high level of morbidity, unavailability and poor consumption practice of fruits and vegetables, low levels of maternal knowledge are presumed to escalate VAD prevalence in the Region. The 1980/81 study, suggested that, although children in the pastoral zone consume dairy products, the concentration of retinol and beta carotene in the diary products are low because of the low level of beta carotene in the fodder consumed by the animals due to the arid nature of the environment (48).

Several studies consistently, indicated that the prevalence of VAD in the SNNPR is low (48, 54). This study also confirmed the fact that VAD is indeed mild in the SNNPR. Relatively, better availability and consumption practice of fruits and vegetables might be implicated as the most likely reasons for the low levels of VAD in SNNPR. The 1980/81 study attributed the low prevalence of xerophthalmia in the Enset zone to the relatively high intake of kale and cheese that are eaten together with Enset products, as reflected in high serum ß –carotene levels observed at the time of the study (48).

Neither pocket nor region specific studies are available in Benishangul-Gumuz Region. Based on the findings of this study however, it can be concluded that the magnitude of VAD (bitot's spot) is moderate in the Region

Relatively high prevalence rates of bitot's spot were observed in Addis Ababa, Harari and Dire Dawa. High prevalence rates were also observed in some cities in the fairly large survey conducted in 1957 (47). The comparison of bitot's spot prevalence rates between predominantly rural and predominantly urban areas, however, showed that the prevalence rate of bitot's spot in predominantly rural areas is significantly higher compared to the prevalence rate of bitot's spot in predominantly urban areas. The low bitot's spot prevalence rates in urban areas than in rural areas can at least partially be explained by the observations related to relatively better access to vitamin A rich foods and comparatively good practices of consumption of vitamin A rich foods in urban areas.

Among the indicators of subclinical vitamin A status, serum retinol level, along with other supportive indicators (clinical, ecological, socio-economic) is also used in the assessment of the levels of vitamin A deficiency in a community/population. Based on the WHO recommendations, the national prevalence rate of subclinical VAD found in this study is several fold higher than the WHO cut off points indicating public health significance and nearly two times higher than the cut-off points indicating serious levels. When the information on morbidity, availability and consumption of foods rich in vitamin A is considered, the seriousness and wide-spread occurrence of subclinical vitamin A in Ethiopia is readily evident.

The prevalence of subclinical VAD is also high in Afar, Oromiya and Amhara regions, corroborating with the clinical findings. Moreover, the regional prevalence rates of subclinical vitamin A appear to be supported with health, ecologic and socio-economic findings. Afar, Oromiya and Amhara regions are characterized by high morbidity rates, low vegetable and fruit availability, poor practice of consumption of fruits and vegetables and poor maternal awareness related to vitamin A nutrition.

Discrepancies in the prevalence rates of bitot's spot and the prevalence of low serum retinol levels are observed in some regions. For example, while the prevalence rate of bitot's spot was moderate in Oromiya, the prevalence rate of low serum retinol levels was high. Similarly, while the prevalence rate of bitot's spot was highest in Amhara, the prevalence rate of low serum retinol levels is only moderately high. Such discrepancies are reported in other studies as well. In a study in Ethiopia, it was shown that among children, who had bitot's spot, 20.5% had normal serum levels and conversely, among children who had no clinical signs, 52.5% had low serum retinol levels (48). In another study, it was found that about 20% children with night blindness and 10% of children with both night blindness and bitot's spot had higher serum retinol levels (61). The explanation for the discrepancies lies on the fact that the various clinical and subclinical indicators measure different stages in the progression of vitamin A status, as already discussed above. Serum retinol levels indicate mild to moderate conditions, night blindness and bitot's spot indicate moderate conditions, while corneal xerophthalmia indicates serious conditions. Therefore, it is possible that high prevalence of subclinical vitamin A deficiency and low prevalence of clinical vitamin A deficiency or vice-versa could be observed in a study conducted in a single community or population. Based on this fact, it is also apparent that none of the indicators can be used as 'golden standard' on which other indicators are validated (31,38).

There are conflicting opinions about the association of VAD with age and sex as discussed in the introduction section. Some studies reported that male children are more at risk than female children (48, 50, 65), while a few other studies reported lack of difference in the prevalence of clinical and subclinical VAD among male and female children (66). In the 1980/81 National Survey, it was speculated that the difference might be due to the fact that female children are benefited as they usually stay at home, while male children stay out with older siblings looking after cattle (48). As discussed in the introduction section, there appears to be some consensus on the fact that children between the ages of two years and five years are more at risk compared to other age groups (27, 48, 63, 64). Particularly, the study on the risk factors among children in slums of India clearly showed that xerophthalmia rate increases with increasing age and picks at 5-6 years (95). In addition, another study on the risk factors for xerophthalmia in the Republic of Kiribati, similarly, showed that the prevalence of xerophthalmia was significantly higher among older children compared to the prevalence rates among younger children (96).

While male children and older children were found to be more at risk of clinical vitamin A deficiency compared to female children and younger children in this study, no association was observed between subclinical VAD with age or sex. Neither marked difference in subclinical VAD between male and female children nor discernable trend in age was seen. These findings confirm the assertions regarding lack of consensus in the associations of sex to vitamin A deficiency. The discrepancies observed regarding the association of sex to vitamin A, might suggest that the differential risk to sexes depends on the socio-economic and cultural contexts of communities studied rather than the biological makeup.

The study on the risk factors among children in Indian slums indicated a higher prevalence of xerophthalmia among children with birth order of four and above, children belonging to illiterate mothers and children belonging to households of family size of 6 and above, compared to their respective counterparts (95). Repeated and short spaced deliveries are known to deplete nutrients, compromising the capacity of mothers to adequately nourish their children. This assertion is supported by the findings of this study. Maternal educational status and maternal knowledge about nutrition and specific nutrients are believed to play a substantial role on nutritional status of children (69, 70, 71). Although maternal education categorized as 'can not read or write' and 'literate' did not show significant association with subclinical vitamin A deficiency, knowledge of mothers regarding the importance of vitamin A was found to be strongly associated with subclinical vitamin A deficiency even after controlling for other variables. Knowledge of the mother regarding the functions of vitamin A, sign/symptoms/consequences of vitamin A and foods rich in vitamin A is generally poor across the nation. Despite the health education for decades, the knowledge of mothers is still far from satisfactory. The fact that the knowledge about vitamin A was poorest in Afar, Amhara and Oromiya regions tend to suggest that low levels of awareness might nave escalated the prevalence of VAD in those regions.

The fact that preschool and primary school children from Muslim households are more affected by vitamin A deficiency is highlighted. Differences in nutritional status between the Muslim and Christian households as observed in this study have been reported in other studies as well (48, 98). Obviously, religion per se can not be accounted for the variations in vitamin A and nutritional status. Religion exerts impacts through its influence in socioeconomic status, education, health and nutritional practices. Therefore, the difference in vitamin A status of children from Muslim and Christian households is obviously due to the difference in other immediate and underlying causes. The National vitamin A survey of 1980/81 implicated large family sizes of Muslim households, (as a result of having more wives), as a possible explanation for the increased prevalence of vitamin A deficiency among Muslim children (48). The lack of association of household size with vitamin A deficiency in this study tends to suggest to the contrary that household size may not be a strong explanatory factor for the high prevalence of vitamin A deficiency among Muslim children.

The negative role of disease in exacerbating vitamin A deficiency was detailed in the introduction section. The common childhood illnesses such as diarrhea, respiratory tract infections, fever, malaria, parasitic infections are known to exacerbate VAD (75, 76, 96, 99). The national weighted proportion of children who had at least one illness was high and deserves attention by its own merit. The study identified sickness in the fifteen days prior to the survey as one of the risk factors precipitating vitamin A deficiency among preschool and primary school children. Given that nearly half of the preschool children were sick in the fifteen days prior to the survey, and based on the findings that sickness is the strongest predictor of vitamin A deficiency, it can be speculated that much of the vitamin A deficiency in Ethiopia might have been precipitated due to illness.

Various institutions in many regions have been implementing supplementation of vitamin A through oral delivery of the nutrient. The potential contribution of VAS in preventing VAD was confirmed in this study. Preschool children who reported to have taken VAS at least once over the year preceding the survey were found to be less at risk of vitamin A deficiency.

Although several factors are known to contribute towards vitamin A deficiency, most often in synergy, inadequate consumption of the nutrient appear to outweigh all other causes. Human beings obtain dietary vitamin A (provitamin A) from plant sources, such as, dark green leafy vegetables, red/yellow vegetables, fruits and preformed vitamin A from animal sources such as liver, meat and eggs. Much of the vitamin A, other micronutrients and minerals in developing countries are obtained from plant sources, because livestock sources are beyond the reach of most of the poor, underlining the fact that micronutrient status in general and vitamin A status in particular is strongly linked to the availability and consumption of vegetables and fruits in developing countries. It is estimated that over 80% of vitamin A in developing countries is supplied by fruits and vegetables (1).

Fruits and vegetables play a number of important roles in human health and nutrition in addition to preventing vitamin A deficiency. They provide antioxidants such as vitamin A, vitamin C and vitamin E that are important in neutralizing free radicals (oxidants) known to cause cancer, cataracts, heart disease, hypertension, stroke and diabetes. Fruits and vegetables provide foliate and potassium that are known to prevent birth defects, cancer, heart disease, hypertension and stroke. Fruits and vegetables are good sources of minerals such as iron, zinc, calcium, potassium, and phosphorus and contain ample fiber which is known to enhance digestion and bowel movements (100, 101, 102). The natural sugar contained within fruits is essential for the effective maintenance of the immune system and the body's natural defense mechanisms (101). WHO places low fruit and vegetable consumption among its twenty risk factors for global mortality, just behind the better known killers such as tobacco use and high cholesterol levels (103)

Cognizant of these facts, FAO/WHO recommends 400 gram of fruits and vegetables per day or alternatively five servings a day; at least two servings of fruits and three servings of vegetables (104). Moreover, experts recommend consumption of fresh, frozen, dried, or canned fruits and vegetables of a variety of colors and kinds, with more emphasis to dark-green leafy vegetables and orange fruits and vegetables (105, 106).

Agreeably, among several health and nutrition benefits of ensuring adequate consumption of fruits and vegetables, prevention of vitamin A deficiency appears to be the most important one, especially in developing countries. A study on the risk factors for xerophthalmia in the republic of Kiribati showed that the prevalence of xerophthalmia was significantly higher among children who consumed less fruits and vegetables (77, 98).

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The findings of this study showed that the practice of consumption of vegetables and fruits in Ethiopia is suboptimal. Majority of the children did not at all eat either vegetable or fruit over the week preceding the survey and when the proportion of children who have eaten adequately (three times or more in a week) is considered, it is apparent that insignificant fraction of the children have consumed sufficiently. Based on WHO's recommendations to consider a community/population as at risk community when less than 75% of the preschool age children consume vitamin A rich foods at least three times a week (38), the population of Ethiopia obviously can be considered as 'at risk population'. This assertion is clearly supported by the findings of the case control study which showed that inadequate consumption of vegetables is the most important risk factor predisposing primary school students to VAD. The proportion of children who did not eat vegetables even once, let alone three times, in a week was greater than 75% in Afar and Tigray and close to 60% in Addis Ababa and Amhara regions, highlighting the suboptimal fruit and vegetable consumption practice in Ethiopia. FAO estimates that Ethiopians eat less than 100 gram of fruits and vegetables/per day, (equivalent to medium sized carrots), which is less than a quarter of the recommended fruit and vegetable consumption (107).

Although this research did not explore the reasons why vegetables and fruits are less consumed in Ethiopia, a few likely reasons can be forwarded based on the dietary habits in the country. In most parts of the country, the diet is monotonous, for example consisting of injera (thin bread made up of flour of a cereal known as 'teff) and wot (sauce of lentils, pea, beans), livestock products and cereals or root crops and legumes. Moreover, there is a perception by the population that the monotonous diet is adequate and superior to vegetables. In most communities vegetables are considered as inferior foods, consumed only when general food shortages prevail. The results of the analysis of vitamin A content of foods, however, clearly indicated that, vitamin A content of teff and injera, wheat bread and 'kocho', major staple foods in the country, is close to nil while the content in shiro wot is insignificant compared to beta carotene content in some vegetables and fruits.

The fact that livestock products, particularly, liver, meat, butter and eggs are the best sources of vitamin A is well established (1,2). These food sources provide preformed vitamin A (retinol) which is more digestible, readily absorbable and utilizable compared to beta carotene from plant sources. However, most households in developing countries do not afford them. The findings confirm the fact that children in almost all regions do not commonly consume meat and eggs adequately. While it is not difficult to rear chicken, (does not need much space and resources), lack of awareness could be cited as the prime constraint.

It is well established that adequate consumption of oil and fats is important for the digestion and absorption of vitamin A in the intestine. The transport of vitamin A in the body also requires fats and oils (8, 9, 10). When the proportion of households who used oil over the week preceding the survey is considered, it appears that considerable numbers of households do not use oil in Ethiopia, and therefore, could be considered as one of the exacerbating factors.

Comparisons of the beta carotene contents of common vegetables, fruits and staple foods observed in this study and beta carotene contents reported in the Ethiopian Food Composition Tables showed some discrepancies. The values in the Composition Table appear to be underestimated compared with the results obtained in this study. For example the beta carotene content in kale is underestimated by almost three-fold and that of carrot by about 1000 μg. Similarly, the beta carotene content of wheat flour, bread and potatoes are substantially underestimated. The variations are anticipated because of the differences in analytical procedures and the instruments used. The analysis that generated the Food Composition Table was based on open column chromatography for extraction and spectrophotometer for quantification, while HPLC was used for both extraction and quantification in this study. However, there appears to be a general agreement regarding the high beta carotene content in kale and carrots, moderate beta carotene content in spinach, mango and papaw and the negligible amounts in staple foods. The relatively high levels of beta carotene in shiro wot compared to the shiro flour (flour of pea) appears to be due to the ingredients added to the sauce such as pepper and tomatoes.

Lack of access to vegetables and fruits might be considered as a major contributing factor to suboptimal vitamin A intake and through it to vitamin A deficiency in developing countries. The practice of own production and market availability primarily determines access to vitamin A rich foods. In terms of own production, the findings of this survey indicated that the proportion of households who did not produce a minimum of one of the common vegetables (kale, spinach, cabbage, carrot, tomato, pumpkin,) and fruits (mango, papaya, oranges, avocado and banana) at least once over the year preceding the survey is very high in Ethiopia. It should be underscored here that the proportion indicated refers to only those who did not produce at all, not even a single plant of a vegetable/fruit and not even once over the year. When adequacy and seasonality issues are considered, it is obvious that households who produce/cultivate adequate fruits and vegetables in their gardens is indeed negligible in the country.

Production as well as availability of the aforementioned dark green vegetables, red/yellow vegetables and fruits is relatively better in SNNPR and Benishangul-Gumuz regions. Although it is not statistically proved, it can be presumed that the better access might have contributed towards the relatively better vitamin A status in those two regions. Based on the dire situation pertaining to access to these food items in Afar, it can also be speculated that the high prevalence of VAD is partly due to unavailability of these food items.

Much of the soil and climate in many regions in Ethiopia is favorable for vegetable and fruit cultivation, as evidenced by a number of ongoing investments in horticulture. As vegetable cultivation does not require a huge resource, it is possible to produce adequate in urban centers, let alone in rural areas. This is evidenced by successful urban agricultural projects in many parts of the world (108,109). Whatever small plot of land, any space (such as roof) and any utensils can be used to cultivate vegetables in urban areas as shown in the pictures below.

Fig. 5: Demonstration of urban agriculture - using available utensils (from candidate's compound)

Fig. 6: Demonstration of urban agriculture - using available strip of land (from candidate's compound)

Apparently, one of the impediments to own production in Ethiopia is lack of awareness about the importance of fruits and vegetables in the wellbeing of children and women. According to a senior expert at FAO, one of the other reasons for low availability of fruits and vegetables in Ethiopia is due to the preference of poor farmers to grow low risk crops, rather than the high risk vegetable and fruits (107).

Market availability of fruits and vegetables is relatively better compared with own production, but there are regions like Afar and Tigray that might need some kind of interventions. Based on

WHO recommendations suggesting unavailability of dark green leafy vegetables more than six months in a community as indicative of increased risk to VAD (38), many regions can be considered as VAD endemic in Ethiopia.

Comparisons of own production, market availability and consumption practice of vitamin A rich foods between predominantly urban community and predominantly rural community yielded expected results. Homestead gardening is better among rural population, while market availability and consumption of vitamin A rich foods, except consumption of vegetables which was comparable, were better in urban areas.

8. Strength and Limitations of the Study

Albeit some of the inevitable limitations, evaluation of the validity of the methodological provisions and the outcome of the studies revealed robustness of the study. As described below, a number of professionally executed technical and practical activities signify the strength of the study.

As detailed in the introduction section, appropriate study designs and sampling procedures were employed in the study. Cross-sectional study design and multi-stage cluster sampling methods, recommended by WHO for national or regional level VAD studies, were employed in the national survey, where as case control study design, recommended for assessing risk factors of rare diseases, such as VAD, was employed.

Relevant indicators recommended by WHO were used. Bitot's spot, night blindness (clinical indicators), serum retinol levels (biochemical/subclinical indicators) and a number of ecologic and socio-economic indicators were used in the study. The findings are presented/discussed comprehensibly as suggested by WHO.

Adequate sample sizes that enabled reporting at regional and nation levels were included in the study. Generating national level information on vitamin A deficiency has become possible after twenty eight years and information at region level as well as rural and urban settings were made available for the first time. Although two regions were not included in the study, the results obtained from the nine regions can be considered national, because the two regions constitute a very small fraction of the total population of Ethiopia.

The sampling approaches strictly adhered to the standard procedures pertaining to multi-stage cluster sampling methods. The study clusters were randomly selected from the list of peasant and urban dwellers associations available at regions and only a few extremely difficult clusters were replaced following the same random selection procedures.

Systematic sampling procedures were strictly followed in the selection of samples and replacement was again done following standard procedures. High level medical professionals (medical doctors) undertook the clinical examinations and senior lab technicians oversaw blood collection, transportation and analysis of blood serum retinol. Similarly, high level supervisors, enumerators and data managers were involved in data collection, quality assurance and data management. Reliability of the data was ascertained through intensive training, piloting and standardization.

The correspondence of much of the results to expectations and theoretical constructs is another indicator of validity of the study. Magnitude of the problem in terms of clinical and biochemical indicators is within the expectations (expectations based on previous studies). The observed urban rural differences in magnitude of the problem, availability and consumption of fruits and vegetables are within the expectations (expectations based on day to day observations). The risk factors identified, such as inadequate consumption of vegetables, sickness, lack of awareness among mothers are within the theoretical constructs.

Lack of data on the actual quantities of the vegetables, fruits and foods consumed by the children and lack of information on the quantities of the vegetables and fruits produced/cultivated by the households as well as lack of reliable information on socio-economic status can be considered as some of the limitations of the study. Lack of information on nutritional status, which could have expounded the impacts of malnutrition on vitamin A deficiency, can also be considered as one of the limitations of the study. In surveys as big as this one, the challenges of capturing the actual amount of foods children consumed and the actual amounts of fruits and vegetables households produced as well as measuring height and weights for the assessment of nutritional status is apparently obvious.

As the focus of the study was on availing information to regions, data on agro-ecology that could have yielded useful information was not considered. This is also one of the limitations of the study.

As information on some of the variables, such as morbidity, vaccination, availability, and consumption were collected retrospectively, inherent recall bias is expected. In addition, as a result of the broadness of the study in terms of geographic coverage and socio-economic diversities, verifications of the validity of some of the information were not done. For example, although it is believed that most of the mothers correctly know the major ailments of their children, it would have been useful, if their morbidity reports were validated against health professional's examination results or judgments. But due to the above mentioned reasons, such validations were not done. Moreover, collapsing categories of some variables in to fewer categories (for example; prevalence of various diseases in to 'ill' and 'not ill'; proportions of children who consumed various amounts in to 'consumed at least once' and 'not at all'; proportion of households who have cultivated various types and amounts of vegetables and fruits as 'produced/cultivated' and 'not at all produced/cultivated') is expected to compromise the strength of the results. This was done in order to permit statistical tests, because many categories of variables most often contain inadequate proportions to allow statistical tests to examine associations and relationships. For example, the prevalence of each disease among students is inadequate to examine the net effect of each of them on vitamin A status using multivariate analysis.

9. Conclusion

The study revealed that the national prevalence rate of clinical vitamin A deficiency (bitot's spot) is more than three times higher than the WHO cut-off points indicating public health significance and that the prevalence of subclinical vitamin A deficiency (serum retinol levels) is nearly two times higher than the WHO cut off points indicating serious levels.

The study showed that although the magnitude varies from region to region, bitot's spot prevalence and the prevalence of subclinical VAD in all regions are higher than the WHO cut off points. However, vitamin A deficiency (clinical and subclinical) appeared to be serious in Amhara, Afar and Oromiya regions.

Although vitamin A deficiency (clinical) was significantly higher in predominantly rural areas compared to predominantly urban areas, prevalence rates in Addis Ababa, Harari and Dire Dawa (predominantly urban areas) was still higher than WHO cut off points, highlighting the fact that VAD can constitute public health problem in bigger towns as well.

The study showed that the weighted national prevalence rate of maternal night blindness is nearly two times higher than the WHO cut-off points and that the prevalence rate in Tigray region was extremely high compared to other regions.

The high national morbidity rate was highlighted in the study. The morbidity rate was markedly high in some regions, particularly in Amhara, Afar and SNNPR. The high morbidity rate is presumed to have aggravated VAD in Amhara and Afar. In addition, the study also confirmed the strong negative contributions of morbidity to vitamin A deficiency.

The study confirmed the fact that vitamin A supplementation at least once over a year play an important role in preventing vitamin A deficiency

Poor levels of maternal knowledge regarding the importance of vitamin A across the nation were observed and the strong association between the levels of awareness and vitamin A deficiency were highlighted in the study.

The study revealed an increased risk of Muslim preschool age children to subclinical vitamin A deficiency, increased risk of male and older preschool age children to clinical vitamin A deficiency and increased risk of Muslim school children to clinical vitamin A deficiency compared to their respective counterparts.

The study showed extremely low levels of own production/cultivation of common vegetables and fruits across the country. Own production/cultivation of common vegetables and fruits was found to be worse in predominantly urban areas compared with the predominantly rural areas.

The study indicated that availability of common vegetables and fruits in the markets is relatively better compared with own production/cultivation situation. Availability of common vegetables and fruits in the markets was found to be better in predominantly urban areas compared to predominantly rural areas.

Sub-optimal consumption of vegetables, fruits, meat, egg and oil were highlighted in the study. Except for consumption of vegetables, which was comparable, consumption of fruits, meat, egg and oil were significantly better in predominantly urban areas compared to predominantly rural areas. Moreover, the strong association of vegetable consumption with clinical vitamin A deficiency among primary school students was highlighted.

The results of the analysis of the contents of foods showed higher amounts of vitamin A compared with the values reported in Food Composition Tables. Moreover, the findings showed higher amounts of vitamin A in vegetables, particularly in kale and carrots, and no or negligible amounts in staple foods.

10. PROGRAMATIC IMPLICATIONS AND RECOMMENDATION

10.1. Overall programmatic implications of the study

This thesis has generated information that will have practical implications for programming, policy/strategy and research activities pertaining to prevention and control of vitamin A deficiency in Ethiopia.

- The up-to-date and disaggregated information on the magnitude and distribution of VAD, will be used for prioritization, planning, targeting, monitoring and evaluation purposes.
- The disaggregated information on the risk factors among preschool and school age children will be used for designing national and region specific interventions.
- Information on the production and availability of vegetables and fruits will be used for designing long-term and sustainable food based agricultural interventions.
- Information on dietary consumption and contents of vitamin A in foods will be used for designing IEC/BCC interventions and to strengthen nutrition curriculum and up date teaching materials.
- The information generated will be used to evaluate the impact of the interventions and the trend of vitamin A deficiency in Ethiopia.
- The information generated will also be used as a benchmark on which the impacts of future deliberations, particularly the currently launched National Nutrition Program (NNP) will be evaluated.

10.2. Specific recommendations

Below are some of the specific recommendations relevant to policy/strategy, targeted interventions, surveillance and research needs.

Policy and strategy needs

- Development and implementation of agricultural policies and strategies to facilitate production of fruits, vegetables and livestock products is recommended. The strategy must guide how the health and agricultural extension programs are strengthened and coordinated, how sufficient material and technical support to communities are delivered and how community awareness creation activities can be strengthened.
- Development and implementation of school health and nutrition policy and strategy to promote the awareness of the students regarding the importance of vitamin A is recommended. The policy/strategy must insure that vitamin A is adequately covered in the curricula, schools have backyard gardening programs and adequate practical knowledge regarding cultivating, harvesting and preparations of vitamin A foods are imparted.

Intervention needs

- Continuation and intensification of the ongoing periodic vitamin A supplementation (VAS) by ensuring universal coverage, timeliness and safety is recommended.
- Strengthening attempts aimed at enhancing the consumption of vegetables, fruits, oil and livestock products is recommended. Empowering health and agriculture extension workers towards bringing behavior change among mothers and the community is necessary. Households must be taught about the importance of consumption of fruits and vegetable in human health and nutrition, particularly in the growth and development of infants and children.

- Strengthening efforts to enable households to produce/cultivate their own vegetables and fruits is recommended. Communities must be technically supported to enable the cultivation of fruits and vegetables in their backyard gardens.
- Intensifying attempts to improve the health status of children through strengthening the ongoing health extension program and strengthening health services is recommended.
- Strengthening efforts to improve women's awareness regarding the importance of vitamin A, through building the capacity of the health extension workers to deliver appropriate, adequate and consistent behavior change messages is recommended.
- Priority and focus in VAD interventions should be given to Amhara, Afar and Oromiya regions. Attention should also be given to Addis Ababa and Dire Dawa city administrations as well as Harari National Regional State.
- Interventions aimed at improving maternal vitamin A nutrition, particularly, postpartum supplementation should be pursued.
- The discrepancy observed in the amounts of vitamin A from the values reported in food composition tables suggests the need to up date the food composition tables by using the more sensitive HPLC methods.

Surveillance needs

- Mechanisms to monitor vitamin A status must be established. These include development of simple monitoring tools (consisting of simple and measurable indicators regarding availability and consumption of vitamin A containing foods in the community), empowering health extension workers to assess the situation and report periodically, and establishing/strengthening the health management information system (HMIS) that allows the flow of information from the grass roots to higher levels with proper feedback mechanisms.
- Conduct serial cross-sectional surveys at national, regional and sub-regional level

periodically (e.g. in 5 years interval) using biological indicators and validate the reports from routine data using such surveys.

Research needs

- The increased risk of Muslim preschool and primary school children to vitamin A deficiency merit an in depth and well designed investigation. Qualitative ethnographic studies are needed to expound the culturally rooted causes.
- Similarly, the increased risk of male and older preschool age children to clinical vitamin A deficiency requires further in-depth assessments to expound the reasons.
- The reasons why Ethiopians do not adequately produce and consume vegetables and fruits must be investigated.
- As this study did not consider agro-ecology, studies related to the variations in magnitude of the problem, availability and consumption of fruits and vegetables among various agro-ecologies is recommended

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DECLARATION

I the undersigned declare that this thesis is my original work and has never been presented in this or other university and that all the source materials used for the dissertation have been duly acknowledged.

Name --

Signature ---

Date of submission --

ANNEXES

Annex 1: Ocular examination and morbidity information

Identification:

Questionnaire Number -------------

1) Region_______________________________________
2) Woreda_______________________________________
3) Name of PAs/UDA___________________________
4) Name of the mother___________________________
5) Name of the child______________________________
6) Sex (1=male, 2=female) --
7) Age of the child (in months) ---

Morbidity and Night blindness

8) Did the child experience any illness in the past 2 weeks? (1=yes 2=no)--------

9) If yes what was it? (1=Diarrhea 2=cough 3=fever 4=malaria 5=eye infection 6=intestinal parasites 7=measles 8=other/specify___________) -------

10) Did the child have history of measles? (1=yes 2=no 3= don't know)-------

11) Did the child receive vitamin A in the last 6 months? (1=yes 2=no 3= don't know)---

12) Does the child have difficulty in seeing during day time? (1=yes; 2=no; 3= don't know) --

13) Does the child have night blindness? (1=yes; 2=no; 3= don't know)---------

14) Did the mother have difficulty in seeing at daytime during her last pregnancy (last pregnancy should not exceed 5 years) (1=yes; 2=no; 3= don't)--------------

15) Did the mother have night blindness during her last pregnancy (last pregnancy should not exceed 5 years) (1=yes; 2=no; 3= don't)---------------------------------

Ocular examination

16) Does the child have Bitot's spot? (1=no; 2=right eye; 3= left eye; 4=both)--
17) Does the child have corneal xerosis? (1=no; 2=right eye; 3= left eye; 4=both)
18) Does the child have ulceration? (1=no; 2=right eye; 3= left eye; 4=both)--
19) Does the child have corneal scar (1=no; 2=right eye; 3= left eye; 4=both)—

Annex 2: Household Questionnaire

I. Identification

1. Name of the child---
2. Identification number---
3. Name of the household head
4. Region---
   (1=Afar; 2=Tigray; 3=Amhara; 4=Addis Ababa; 5=Oromiya; 6=SNNPR;
   7=Gambela; 8= Benishangul-Gumuz; 9=Somali; 10=Harari; 11=Dire Dawa)
5. Woreda ____

6. Peasant/urban dwellers Association ____

7. Name of the village ____

II. Household characteristics

8. Sex of household head:- (1=male; 2=female)---

9. Education level of household head:- (1=can not read or write; 2=read and/or write;
   3=1- 6 grade; 4=7- 12grade; 5=above grade 12) --

10. Religion of the household head (1=Orthodox; 2=Protestant; 3=Muslim; 4=Catholic;
    5=traditional; 6=other/specify _________________________) ----------------------------------

11. Number of household members ---

12. Number of children under five ---

13. Occupation of the household head (1=mixed farming; 2=livestock rearing;
    3=trader; 4= civil servant; 5= factory worker; 6= handicraft; 7=other (specify) ________) ----------------

14. Estimated landholding in hectare---

15. Number of cows giving milk currently ---

16. Number of goats giving milk currently ---

17. Number of camel giving milk currently ---

18. Roof type of the house: - (=grass; 2=corrugated iron; 3=stone/mud. 4=other/specify _____
19. Where does the family dispose human excreta? (=backyard garden around the house;
    2=open field; 3=pit latrine 4=other/specify_______________________)-------------------

20. How much sugar did your family use last week? _________________________________

21. How much oil did your family use last week? ___________________________________

22. How many times did your family consume meat over the year? ----------------------------

23. How many times did your family consume liver over the year? ----------------------------

III) Production and consumption of Vitamin A rich foods

Food/crop type	Season produced (see codes I below)	Season available in the market (see codes below)	No. of times the index child has consumed last week
Kale			
Pepper			
Spinach			
Haleko			
Cassava leaves			
Carrots			
Tomato			
Pumpkin			
Yellow/orange sweet potato			
Mango			
Papaw			
Orange			
Banana			
Avocado			
Kulkwal			
Egg			
Milk			
Butter			

Codes I for season produced; 1=not produced at all; 2=throughout the year; 3=September through December;4=January through April; 5=May through August; 6=other/ specify ___________________________________

Codes III for season available in the market; 1=not available at all; 2=throughout the year; 3=September through December; 4=January through April; 5=May through August; 6=other/ specify __________

IV. Child characteristics

24. Age of the child in completed months --

25. Sex of the child (1=male; 2=female) --

26. Does the child have vaccination card? (1=yes; 2=no)-----------------------------------

If yes, fill the following (Question 27 to 31) from the card; if no go to question 32).

27. BCG (1=yes; 2=no) --

28. DPT (1=none; 2=one time; 3=two times; 4=three times) -----------------

29. Polio (1=none; 2=one time; 3=two times; 4=three times; 5=more than three times) --

30. Measles (1=yes; 2=no) --

31. Vitamin A (1=none; 2=one time; 3=two times; 4=three times; 5=more than three) ----------------

32. Ask whether the mother knows about the vaccination status of the child (1= I do not know, 2=not all; 3= partially; 4= complete) ------------------------------------

33. Show vitamin A capsule to the mother and ask whether she recalls that the child has taken (1= I do not know, 2=not all; 3= has taken once over the year; 4= has taken twice over the year) ---

34. Did the child have respiratory tract infection in the last two weeks? (1=yes; 2=no)-------

35. Did the child have diarrhea in the last two weeks? (1=yes; 2=no) --------------------------

36. Did the child have malaria in the last two weeks? (1=yes; 2=no) --------------------------

37. Did the child have measles in the last two weeks? (1=yes; 2=no)--------------------------

38. Was he/she sick due to parasitic worms (seen or told by health professional) in the last two weeks? (1=yes; 2=no) --

39. Did he/she have other illness in the last two weeks? (1=yes; 2=no)-------------------------

If yes, specify ________________________________

40. What is the birth interval B/N this child and older child? (1=less than a year; 2=between one year and two years; 3=above two years) -------------------------------------

41. What is the birth interval B/N this child and younger child:- (1=less than a year; 2=between one year and two years; 3=above two years) --------------------------------------

V. Maternal characteristics

42. Age of the mother ---

43. Education status of the mother (1=can not read or write; 2=read and/or write; 3=1-6grade; 4=7-12grade; 5=above grade12) --

44. Parity level of the mother (1=nil; 2=one; 3=two; 4=three to five; 5=more than five)-------

45. Can you list the functions of vitamin A? (1= I do not know; 2=for the normal functioning of the eye; 3=protection from disease; 4=growth and development; 5=reproduction); 6= others/specify ________________________)-------------------------------

46. Can you list the sign/symptom and consequences of Vitamin A deficiency? (1= I don't know; 2=night blindness; 3= dryness of the eye; 4=ulceration of the eye; 5= eye scar; 6=blindness; 7=increased susceptibility to disease; 8=death; 9= other/specify _________________________________)---

47. Can you list the foods rich in Vitamin A? (1=I do not know; 2=dark green leafy vegetables; 3=fruits; 4=meat; 5=egg; 6=liver; 7=carrots; 8=tomatoes; 9=pumpkin; 10=butter; 11=other/specify ___________________________)-------------------------------------

Annex 3: Questionnaire for case control study

I. Identification

1. Woreda --

2. Name of the school --

3. Name of the child---

4. Enrolled as 1=case, bitot's spot; 2= case, night blindness 3=control -------------------

5. Age---------------------

6. Sex (1=male; 2=female) -----------

7. Grade--------------------------------------

II. Household characteristics

8. Religion of the family (1=Orthodox; 2=Protestant; 3=Muslim; 4=Catholic; 5=traditional; 6=other/specify ________________________) -----------

9. Number of household members ------------------------------------

10. Number of children under five -------------------------------------

11. Occupation of the family (1=mixed farming; 2=livestock rearing; 3=trader; 4= civil servant; 5= factory worker; 6= handicraft; 7=other (specify) ______________) --------------------

12. Number of cows/goats giving milk currently -------------

13. Do you usually drink milk? (1=yes; 2=no) --------

14. Do you have egg laying hens at home? (1=yes; 2=no) --------

15. How often do you eat egg? -------------

16. Family ownership of functional radio (1=yes; 2=no) --------

17. Roof type of the house: - (=grass; 2=corrugated iron; 3=stone/mud 4=other/specify ________________) -----------------

III. Morbidity

18. Did you have respiratory tract infection in the last two weeks? (1=yes; 2=no)-------
19. Did you have diarrhea in the last two weeks? (1=yes; 2=no) --------------------------
20. Did you have malaria in the last two weeks? (1=yes; 2=no) --------------------------
21. Did you have measles in the last two weeks? (1=yes; 2=no)--------------------------
22. Were you sick due to parasitic worms (seen or told by health professional) in the last two weeks? (1=yes; 2=no) --
23. Did you have other illness in the last two weeks? (1=yes; 2=no) ---------------
If yes, specify ________________________________

IV. Knowledge about vitamin A

24. Can you list the functions of vitamin A? (1= I do not know; 2=for the normal functioning of the eye; 3=protection from disease; 4=growth and development; 5=reproduction); 6= others/specify _______________________) ----------
25. Can you list the sign/symptom and consequences of Vitamin A deficiency? (1= I don't know; 2=night blindness; 3= dryness of the eye; 4=ulceration of the eye; 5= eye scar; 6=blindness; 7=increased susceptibility to disease; 8=death; 9= other/specify ______________________________) -----------
26. Can you list the foods rich in Vitamin A? (1=I do not know; 2=dark green leafy vegetables; 3=fruits; 4=meat; 5=egg; 6=liver; 7=carrots; 8=tomatoes; 9=pumpkin; 10=butter; 11=other/specify _________________) -------------

V. Food consumption

27. List the main foods you usually eat

28. List the types of food you ate for breakfast yesterday

29. List the types of food you ate for lunch yesterday

30. List the types of food you ate for dinner yesterday

31. If you ate snack yesterday list the types of food you ate

32. Has your family grown vegetables and fruits in the last six months? (1=yes; 2=no) -----

33. If yes, please tell us the types of vegetables and fruits and how they were utilized

Types	Utilization
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34) Consumption of vitamin A containing foods

Food/crop type	# of days the child has consumed the foods last week	Source of the foods 1=own; 2=market; 3=both; 4=other
Kale		
Green Pepper		
Spinach		
Cabbage		
Y/O sweet potato		
Carrots		
Tomato		
Pumpkin		
Mango		
Papaw		
Orange		
Banana		
Avocado		
Egg		
Milk		
cheese		
Meat		
Liver		
fish		

Annex 4: Manuscripts 1: Magnitude and Distribution of Vitamin A Deficiency in Ethiopia

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ABSTRACT

Background

Several surveys conducted over forty years have shown that vitamin A deficiency is a serious public health problem in Ethiopia. In order to effectively address the problem, up to date and comprehensive information on the magnitude and distribution of vitamin A deficiency is needed.

Objective

The national vitamin A survey was aimed at assessing the national and regional prevalence rates of vitamin A deficiency in Ethiopia.

Methods

The survey employed multi-stage, cluster-sampling approach and a cross-sectional study design. A total of 23,148 children aged 6-71 months were examined for the clinical signs/symptoms and among them blood samples were collected from 1200 systematically selected children for serum retinol analysis.

Results

The findings indicated a national Bitot's spot prevalence rate of 1.7%; a national child night blindness prevalence rate of 0.8% and a national maternal night blindness prevalence rate of 1.8%. Nationally, 37.7% (95% CI; 35.6%-39.9%) were found to have deficient serum retinol levels, 50.7% were found to have been sick over fifteen days and 22.6% had received vitamin A supplements over the year. Male children ($p<0.05$), older children ($p<0.05$) and rural children ($p<0.05$) were found to have been more vulnerable to clinical vitamin A deficiency compared to their respective counterparts.

Conclusions

The study confirmed that vitamin A deficiency was a serious public health problem in Ethiopia. Intensification of the ongoing vitamin A supplementation, post partum vitamin A supplementation for mothers, intensifying efforts to improve the health status and promotion of production and consumption of fruits and vegetables are recommended.

Key words: Clinical vitamin A deficiency; subclinical vitamin A deficiency; serum retinol levels; Ethiopia

INTRODUCTION

Vitamin A is a fat-soluble vitamin, needed in small quantities for several metabolic activities in the body. When vitamin A intake is below the requirement, a number of manifestations collectively known as Vitamin A deficiency disorders (VADD) occur. **The major consequences of VADD include impairments in the visual system, blindness and increased susceptibility to infection.** Studies have shown that by improving Vitamin A status, mortality of children can be reduced by 23% [1] and **pregnancy-related** mortality by as much as 40% [2].

Many surveys conducted in the last four decades have consistently indicated high prevalence rates of vitamin A deficiency in Ethiopia. The first study that highlighted the occurrence of vitamin A deficiency (VAD) in Ethiopia was the survey conducted in 1957/58 around Gondar town in Northern Ethiopia [3]. Subsequent study conducted in several sites across the nation in 1958/59 confirmed the wide-spread occurrence of vitamin A deficiency in the country [4]. Based on the recommendations of the study, the then Ethiopian Nutrition Institute (ENI) was established in 1962.

In 1980/81, the Ethiopian Nutrition Institute undertook a fairly large survey that included 6636 preschool age children in 42 urban and semi-urban survey sites representing four agro-ecological zones. The survey indicated an overall Bitot's spot rate of 1%, which is twice the cut-off point (0.5%) set by World Health Organization (WHO), indicating a problem of public health significance [5]. Based on this rate, it was estimated that about 6 to 8 million of the preschool age children in the country were at risk of vitamin A deficiency at that time. The prevalence of Bitot's spot was found to be higher among children in pastoral areas (1.6%), followed in those living in grain cropping (1.1%) cash cropping zones (0.4%) and Enset cropping zone (0.0%). In the overall, among 742 children from whom blood samples were collected, serum retinol levels were deficient among 44% of the children [5].

Beginning from 1980/81 to 2006 a number of community based surveys have been conducted [6-10]. The findings of almost all surveys unanimously showed that except the Southern Region [5,9] where low levels of vitamin A deficiency have been reported, vitamin A deficiency is a major nutritional problem in most parts of Ethiopia. Vitamin A deficiency problem has always been a serious problem in areas where the diet is predominantly based on a monotonous cereal-legume diet [5,8].

Since the awareness of the problem in 1959, a number of interventions aimed at preventing and controlling vitamin A deficiency have been implemented in the country. Strengthened IEC/BCC activities, along with attempts to promote consumption and production of vitamin A rich foods including livestock foods had been implemented in the sixties through eighties. Beginning from 1989, an attempt was made to reinforce the aforementioned activities, by targeted supplementation of vitamin A via the available health infrastructures of the Federal Ministry of Health (FMoH). In 1995, the Ministry of Health and UNICEF began implementing universal vitamin A supplementation through oral delivery of vitamin A using, EPI and MCH contacts. However, evaluation of the EPI integrated vitamin A supplementation in Kambatta, Alaba, Timbaro Zone of SNNPR conducted in 1997 showed that the program was not implemented as it was anticipated. Lack of awareness at all levels of health care delivery system and inadequate resources were identified as major constraints [11]. Beginning from 1997, the Ministry of Health resorted to bi-annual vitamin A capsule distribution through campaign either as a stand-alone activity or integrated with the National Immunization Days (NID). In 1997 and 1998, the coverage of vitamin A supplementation reached about 70%, but dropped to 30% in 2000 and 2001, as a result of the deaths of children due to incidental choking that occurred during the supplementation. In April 2004, Enhanced Outreach Strategy (EOS) was initiated [12], where vitamin A supplementation was included as the main component of a package (deworming, measles vaccination, nutritional screening, IEC/BCC activities, etc) aimed at enhancing child survival of children aged 6-59 months in 14 woredas of Sidama and Wolliata, Zones of the SNNP Region, and expanded to cover 54 districts by August 2004 and then was scaled up to cover 235 woredas in 2005, all selected because of their vulnerability to drought and chronic food insecurity [13]. Reports showed that VAS coverage reached 11-12% in 2004, 40-67% in 2005 and 82-87% in 2006 [13]. By 2007, except nutritional screening, other EOS activities were extended to all the districts in the country as an initiative referred as Extended Enhanced Outreach Strategy (EEOS). Thus, through EOS and EEOS, all children aged 6-59 months are targeted for vitamin A supplementation in the country. The 2008 EOS coverage survey showed that, in the overall 93% of children aged 6-59 received VAS ranging from 81.5% in Dire Dawa to 98.9% in Tigray region [14].

Agreeably, up to date, comprehensive (national) and disaggregated (regions, sex, age, residence) information on the magnitude of vitamin A deficiency is required for various VAD surveillance activities, such as prioritizing, targeting, monitoring and evaluating the impacts of past and future interventions. The literature search clearly showed that such information indispensable for programmatic endeavors are lacking in Ethiopia. Thus, the national vitamin A deficiency survey was conducted to fill the information gap by generating and availing information on magnitude and distribution of vitamin A deficiency in Ethiopia.

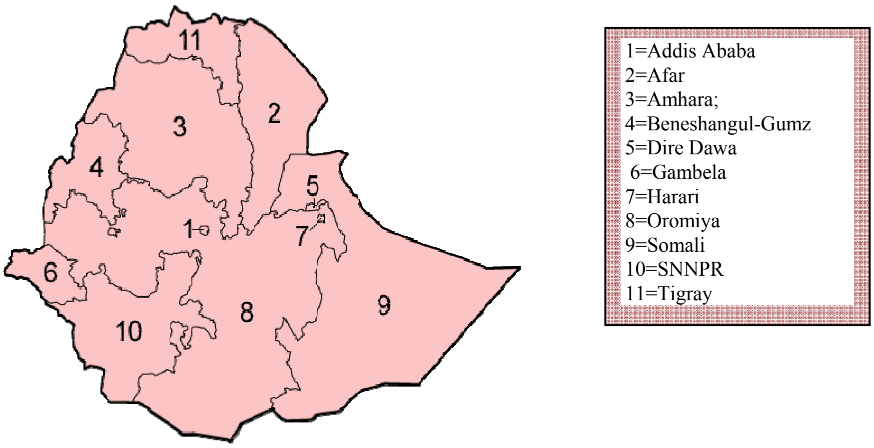
METHODS

The setting

The Federal Government of Ethiopia is constituted by nine regional national states and two urban administrations (Fig. 1). Addis Ababa, Dire Dawa and Harari Administrative regions are predominantly urban centers, while the rest are predominantly rural areas. Afar, Somali and Gambela regions are located in Eastern and Western lowlands and constitute predominantly pastoralist communities. Amhara and Tigray regions are located in the Northern part of the country, constituting predominantly agricultural communities. Oromiya, Southern Nations, Nationalities and People's Region (SNNPR) and Benishangul-Gumuz regions constitute diversified agro-ecologies (highland, midland and lowlands) and diversified dietary patterns.

In predominantly urban areas, as well as in Tigray and Amhara regions, cereals, (injera[7] or bread) and legumes (wot[8]) are the major staple diets (15). In pastoralist areas (Afar, Gambela, Somali and part of SNNPR, Oromiya and Benishangul-Gumuz) livestock products and cereals (porridge and bread of sorghum/maize) are the main sources of food. In the highlands and mid lands of Oromiya, SNNPR and Benishangul-Gumuz regions, cereals and root crops (Yam, cassava, taro, kocho[9], banana, potato etc) are commonly grown and consumed. In general, except in SNNPR and Gambela, the practice of production and consumption of fruits and vegetables is limited across the country [15].

Fig.1. Administrative regions of Ethiopia.



The study was done **between December 2005 and June 2006** in seven regional national states; namely, Amhara, Tigray, Oromiya, Benishangul-Gumuz, SNNPR, Afar and Harari and in the two city administrations, Addis Ababa and Dire Dawa. The Somali and Gambela regional states were excluded for security reasons.

Study design and sample size

The survey employed cross-sectional study design and multi-stage, cluster sampling approach. Equal sample sizes across regions with ultimate weighting of results were adopted since, sample sizes based on population proportions would have yielded insurmountable sample sizes in bigger regions. The number of children included in the clinical survey in each regional national state and city administration was calculated using EPI

[7] Pancake sort of bread made from cereals, mostly 'teff'
[8] Sauce made from pea, lentil or bean flour
[9] Made from a root crop known as 'Enset'

INFO 2004 [16]. Inserting, p=1%[10], confidence interval 95%, error margin = ± 0.5% and design effect of 2, a sample size of 3000 children for clinical examination was obtained. As it was planned to collect blood samples from five percent of the children clinically examined (p[11]=44%, confidence interval= 95%, error margin = ±10.0% and design effect = 1.5) the anticipated number of children for the biochemical assessment was 150 children per region. Therefore, the total number of children expected nation-wide (7 regions and two city administrations) was 27000 for clinical assessment and 1350 for biochemical assessment (serum retinol). Due to several unprecedented problems at the time of the survey, 23148 were clinically examined (86% success rate) and blood samples were collected from 1200 children (85% success rate). Due to insufficient blood, 204 samples were not analyzed.

Sampling procedures

In each regional state and city administration, 30 peasant/urban dwellers associations (the smallest administrative units in Ethiopia) were randomly selected from the list of peasant/urban dwellers associations available at administrative headquarters. Again, in each selected peasant/urban dwellers association one study village (cluster) was selected randomly. In each cluster, 100 children between 6 and 71 months were systematically selected for clinical assessment and among them blood samples were collected from systematically selected 5 children (every 20th child).

Data collection and data processing

In each region, trained physicians undertook the clinical examination and collect information on night blindness. History of night blindness during the recent pregnancy (pregnancy with in recent five years) was collected and corrections were made to exclude mothers who also said that they had difficulty in seeing at daytime. Same procedures were used in collecting information on child night blindness. Information regarding whether the child was sick over 15 days prior to the survey and whether the child has received VAS over six months period were also collected.

Senior laboratory technicians collected blood samples in all regions. All precautions and standard procedures, such as, using disposable syringes and thorough cleansing of the skin, were followed during blood collection. The samples were kept in dark places in icebox until they were transported to nearest health facility for separation of serum from the whole blood. The serum was kept frozen under -80 Degree Celsius until the analysis was done. Retinol analysis was done at EHNRI using High Performance Liquid Chromatography [17]. Accuracy and precision of the analysis was monitored each day by repeated analysis of quality control reference material, SRM 968c obtained from National Institute of Standard and Technology, Gothenburg, USA. Values measured were 97.2±1.2% of the certified values for retinol. Within assay and between assays coefficients of variations were 3.9% and 14.2% respectively.

The study was approved by the research and ethical clearance committee at Ethiopian Health and Nutrition Research Institute (EHNRI). The aim of the study was explained to the caretakers of the children and blood collection was purely based on the written and signed consent of the families. Children who were found to have clinical signs of vitamin A were promptly treated with 200,000 International Units (IU) and incentives of soap and biscuit were given at the end.

RESULTS

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[10] Proportion based on the 44% subclinical prevalence rate reported in the 1980/81 survey

[11] P is the prevalence of subclnical VAD, which was 44% in the national survey conducted in 1980/81

Nationally, almost equal number of female and male children participated in the clinical study (Table 1). Except in Benishangul-Gumuz and Addis Ababa, male children were slightly over represented in other regions. In terms of age, children below two years and children between two to four years were equally and over-represented compared to children aged four to six years.

Nationally, 50.7% of children were sick two weeks prior to the survey (Table 2). More than 60% of the children were sick in Afar, Amhara, and SNNPR. A little over half of the children were sick in Tigray, Benishangul-Gumuz and Harari. The findings pertaining to VAS indicated that in the overall 22.6% received VAS at least once over the year preceding the survey. Proportion of children who received vitamin A supplement (VAS) is significantly higher in Tigray (79.2%) and modest in SNNPR (33.9%) and low in other regions.

The national prevalence rate of Bitot's spot (weighted prevalence rate) was 1.7% with the highest rate in Amhara region (3.2%) followed by the prevalence rate in Afar (2.1%), Oromiya (1.5%), Addis Ababa (1.4%), Harari (1.2%) and Dire Dawa (1.1%) regions (Table 3). Nationally, there were 11 (0.02%) and 16 (0.04%) children who had corneal ulceration and corneal scar respectively. The national prevalence of corrected child night blindness was 0.8% (Table 3). Child night blindness was relatively higher in Harari (1.1%) followed in Amhara (1.0%), Benishangul-Gumuz (1.0%) and Afar (0.9%). The national weighted prevalence rate of maternal night blindness was 1.8% with the highest prevalence in Tigray region (14.1%) followed in Benishangul-Gumuz (5.7%), Afar (1.2%) and Amhara (1.0%) regions (Table 3).

National and regional subclinical prevalence rate (serum retinol <0.7µmole/L) is shown in Table 4. As shown, the national weighted prevalence rate is 37.7% with the 95% CI of 35.6%- 39.9%. The highest prevalence was recorded in Afar (57.3%) and Oromiya (56.0%) regions followed in Dire Dawa (48.0%), Amhara (40.7%) and Harari (35.8%) regions. The lowest prevalence rates were recorded in SNNPR (11.3%) and Tigray (14.3%) regions.

Analysis of the association of sex and age with vitamin A deficiency showed that the proportion of Bitot's spot was significantly ($p<0.05$) higher among male than the female children (Table 5). The distribution of Bitot's spot among the three age categories is also significantly different ($p<0.05$). The prevalence was found to increase with the increasing age. The prevalence of Bitot's spot in predominantly rural areas was significantly higher compared to the prevalence rate in predominantly urban areas. There was no significant difference in the prevalence of subclinical vitamin A deficiency between male and female children, among various age groups as well as between predominantly rural and predominantly urban areas.

DISCUSSION

Initially, the prevalence of clinical signs and symptoms of VAD have been used to assess vitamin A status of a community. However, when it became clear that subclinical deficiency was associated with significant increase in child morbidity and mortality in the 1980s, techniques in the assessment of subclinical VAD began to emerge [18]. The fact that clinical manifestations occur after serious damages to internal tissues had already been inflicted, justified the importance of subclinical assessment. This study employed both clinical and subclinical assessment procedures.

Among several clinical indicators, Bitot's spot, corneal ulcerations and corneal scar are used to assess vitamin A status of the population. The national prevalence of corneal scar is close to WHO cut off point and corneal lesions/keratomalacia are close to two times the WHO cut-off points. The national prevalence rate of Bitot's spot however, is more than three times higher than the WHO cut-off points indicating public health significance. When compared to the 1% prevalence rate of Bitot's spot reported in the 1980/81 survey [5], it is readily evident that the national VAD prevalence rate has increased by nearly 70%. The results signify the fact that the impacts of several interventions put in place since the awareness of the problem in the sixties has not been sufficient to reverse the trend. The high prevalence rate of morbidity and the low levels of VAS observed in this study appear to have exacerbated vitamin A deficiency in Ethiopia. It is also more likely that, the recurrent drought, chronic food insecurity and population explosions might have contributed towards the deterioration in vitamin A status.

Among the regions, the highest prevalence rate of Bitot's spot was recorded in Amhara and Afar regions whereas the lowest prevalence rates were observed in Tigray and SNNPR. Since, the 1980/81 study did not disaggregate the results by regions [5], direct comparisons in regional prevalence rates are difficult. Nevertheless, it appears that some insight can be gained by comparing the cereal cropping zone result of the 1980/81 against the results observed in Amhara and Tigray Regions (Amhara and Tigray Regions belong to cereal cropping zone), pastoral zone results of the 1980/81 against the results in Afar Region (Afar is pastoral region) and Enset cropping zone results against the results in SNNPR (SNNPR region mostly belongs to Enset cropping zone).

Compared to the 1980/81 findings, prevalence rate of Bitot's spot has increased in the Amhara Region. The observed high prevalence of morbidity, poor consumption of fruits and vegetables [16] and the monotonous 'cereal-legume' diet [15] can be considered as the likely factors that might have exacerbated VAD in the Amhara Region. The study by De Sole et al. [6], suggested that the higher prevalence of vitamin A deficiency in the cropping zone can be attributed to the monotonous cereal legume diet. Tigray Region is one of the regions where reduction in the prevalence of Bitot's spot among preschool children was observed. Previous studies indicated high levels of VAD in the Region [10, 19]. Although, it is not confirmed by proper statistical tests, the low prevalence rate observed in Tigray Region is attributable to the relatively high VAS coverage at the time of the survey.

Compared to the pastoral zone results of 1980/81, the prevalence of Bitot's spot has increased in Afar Region. Multiple factors such as high level of morbidity, unavailability and poor consumption practice of fruits and vegetables [15] are presumed to have escalated VAD prevalence in the Region. The 1980/81 study, suggested that, although children in the pastoral zone consume dairy products, the concentration of retinol and beta carotene in the diary products are low because of the low level of beta carotene in the fodder consumed by the cattle due to the arid nature of the environment [5].

Several studies consistently, indicated that the prevalence of VAD in the SNNPR is low [5, 9]. This study also confirmed the fact that VAD is indeed mild in the SNNPR. Relatively, better availability and consumption practice of fruits and vegetables [15] might be implicated as the most likely reasons for the low levels of VAD in SNNPR. The 1980/81 study attributed the low prevalence of xerophthalmia in the Enset zone to the relatively high intake of kale and cheese that are eaten together with Enset, as reflected in high serum beta carotene levels observed at the time of the study [5].

Neither small scale nor region level surveys are available in Benishangul-Gumuz Region. Based on the findings of this study, it can be concluded that the magnitude of VAD (Bitot's spot) is moderate in the Region. Relatively high prevalence rates of Bitot's spot were observed in Addis Ababa, Harari and Dire Dawa. High prevalence rates were also observed in some cities in the fairly large survey conducted in 1958/59 [4]. The comparison of Bitot's spot prevalence rates between predominantly rural and predominantly urban areas, however, showed that the prevalence rate of Bitot's spot in predominantly rural areas is significantly higher compared to the prevalence rate of Bitot's spot in predominantly urban areas. The low Bitot's spot prevalence rates in urban areas than in rural areas can at least partially be explained by the relatively better access to vitamin A rich foods and comparatively good practices of consumption of vitamin A rich foods.

One of the functional consequences of VAD is impaired adaptation to darkness, and hence, the prevalence of night blindness along with other supportive evidences is considered as one of the indicators in assessing VAD status of a population. In areas where vitamin A deficiency is endemic, terms usually exist to describe the situation allowing the collection of more reliable information [20]. Night blindness information collected in non endemic areas could be biased because mothers/caregivers may not notice the effects of night blindness on their children (bumping in to things, failing to grasp things at dusk etc). In Ethiopia, terms such as 'dafint' in Amhara, 'hema' in Oromiya and 'gahami' in Tigray exist, which are all in cereal cropping areas where vitamin A deficiency is known to be endemic, while no terms exist in Enset cropping areas. Therefore, although, the weighted national prevalence rate of child night blindness is not negligible, it may be possible that the prevalence rate of child night blindness could have been underestimated because of the inevitable underestimation in non endemic areas. Maternal night blindness is also used as a proxy indicator of VAD status in a population. The weighted national prevalence of maternal night blindness is nearly two times higher than the WHO cut-off points. The marked high prevalence rate of maternal night blindness in Tigray region, while the prevalence of child night blindness is low, appear to underline the protective role of vitamin A supplementation. As highlighted in this study, most of the children in Tigray had received VAS over six months prior to the survey, while the mothers did not.

Among several subclinical assessment techniques and indicators developed, assessment of serum retinol levels along with other biological, ecological and socioeconomic indicators is being widely used. At individual level, 0.7µmole/lt is recommended by WHO to be used as a cut-off point indicative of presence of subclinical vitamin A deficiency [21]. At a community level, WHO recommends that when 2%-10%, 10%-20% and >20% of children in a population have serum retinol levels <0.7µmole/L, the communities should be considered as mildly deficient, moderately deficient and severely deficient community, respectively. Based on these recommendations, the national prevalence rate of subclinical VAD found in this study is several-fold higher than the WHO cut off point indicative of public health concern and nearly two times higher than the cut-off points indicative of severe levels. The prevalence of subclinical VAD is close to three times higher than the cut off point indicating the serious levels in Afar and Oromiya regions.

Evidence from several sources concurs that preschool age children, particularly children between 3-5 years of age are affected most [5, 22]. However, it appears that consensus or conclusions have not yet been reached regarding the association of sex with VAD, although many studies tend to indicate that male children are more affected compared to female children [6, 23]. One longitudinal study reported no difference in the vulnerability of male and female children to vitamin A deficiency [24]. The 1980/81 national vitamin A survey revealed that more male children are affected clinically, but are equally at risk to subclinical vitamin A deficiency [5]. While male children and older children were found to be more at risk of clinical vitamin A deficiency compared to female children and younger children in this study, no association was observed between subclinical VAD and age or sex. The discrepancies in the opinions regarding the association of sex to vitamin A, might suggest that the differential levels of risk to sexes depends on the socio-economic and cultural contexts of communities studied.

CONCLUSIONS

The national prevalence rates of clinical and subclinical vitamin A deficiency indicate serious levels at the time of the survey. Continuation and intensification of the ongoing periodic vitamin A supplementation (VAS) by ensuring universal coverage, its timeliness and safety; implementing interventions aimed at improving maternal vitamin A nutrition, particularly, postpartum supplementation; strengthening efforts to improve health status and strengthening attempts aimed at enhancing production and consumption of vegetables and fruits are recommended.

Although the magnitude varies, Bitot's spot prevalence and the prevalence of subclinical VAD in all regions are higher than the WHO cut off points. Particularly, the prevalence is markedly high in Oromiya, Amhara and Afar regions. These three regions must constitute priority. The high prevalence observed in Addis Ababa, Harari and Dire Dawa has highlighted the need to also focus on bigger towns. Maternal VAD in Tigray must also receive prompt attention. In-depth investigations pertaining to factors leading to the increased vulnerability of male children and older children to clinical vitamin A deficiency is recommended.

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Table 1: Sex and age distribution of children included in clinical survey by region, 2006, Ethiopia

Region	N	Sex		Age		
		Male	Female	<24 months	25-48 months	49-72 months
Afar	2327	1115 (47.9%)	1222 (52.1%)	948(40.7%)	756(32.5%)	623(26.8%)
Tigray	2883	1498 (52.0%)	1385 (48.0%)	1331(46.2%)	1121(38.9%)	431(14.9%)
Amhara	2681	1390 (51.8%)	1291 (48.2%)	917(34.2%)	1115(41.6%)	649(24.2%)
Addis Ababa	2479	1230 (49.6%)	1249 (50.4%)	855(34.5%)	1047(42.2%)	577(23.3%)
Oromiya	2497	1294 (51.8%)	1203 (48.2%)	854(34.2%)	1015(40.6%)	628(25.2%)
SNNPR	2514	1344 (53.4%)	1170(46.6%)	1182(47.0%)	978(38.9%)	354(14.1%)
Benishangul -Gumuz	2653	1307 (49.3%)	1346(50.7%)	1076(40.6%)	1027(38.7%)	550(20.7%)
Harari	2506	1380 (55.1%)	1126 (44.9%)	810(32.3%)	1126(44.9%)	570(22.7%)
Dire Dawa	2420	1296 (53.6 %)	1124(46.4%)	972(40.2%)	870(36.0%)	578(23.9%)
Total	22960	11849 (51.6%)	11111(48.4%)	8945(39.0%)	9055(39.4%)	4960 (21.7%)

Table 2: Fifteen days morbidity and VAS over the year preceding the survey by region, 2006, Ethiopia.

Region	N	Sick n (%)	Received VAS n (%)
Amhara	2708	1807(66.7%)	433(16.0%)
Oromiya	2509	753(30.0%)	257(10.2%)
Tigray	2902	1517(52.3%)	2298(79.2%)
Addis Ababa	2508	875(34.9%)	2131(15.0%)
SNNPR	2544	1574(61.9%)	862(33.9%)
Benishangul-Gumuz	2671	1470(55.0%)	195(7.3%)
Dire Dawa	2444	789(32.3%)	284(11.6%)
Harari	2528	1420(56.2%)	28(1.1%)
Afar	2334	1524(65.3%)	501(21.5%)
National	23148	11729(50.7%)	5235(22.6%)

Table 3: Prevalence of clinical vitamin A deficiency by region, 2006, Ethiopia

Region	N	Bitot's spot n(%)	Corneal ulceration n(%)	Corneal scar n(%)	Child night blindness n(%)	Maternal night blindness n(%)
Afar	2334	49(2.1%)	2 (0.09%)	2 (0.09%)	21(0.9%)	28(1.2%)
Tigray	2902	21(0.7%)	0(0.00%)	3(0.10%)	27(0.9%)	410(14.1%)
Amhara	2708	88(3.2%)	0(0.00%)	1(0.04%)	28(1.0%)	27(1.0%)
Addis Ababa	2508	34(1.4%)	2(0.08%)	2(0.08%)	12(0.5%)	10(0.4)
Oromiya	2509	38(1.5%)	1(0.04)	1(0.04%)	12(0.5%)	23(0.9%)
SNNPR	2544	14(0.7%)	0(0.00%)	0(0.00%)	18(0.7%)	26(1.0%)
Benishangul-Gumuz	2671	22(0.8%)	1(0.04)	1(0.04%)	27(1.0%)	151(5.7%)
Harari	2528	30(1.2%)	3(0.12%)	2(0.08%)	28(1.1%)	20(0.8%)
Dire Dawa	2444	27(1.1%)	2(0.08%)	4(0.16%)	8(0.3%)	9(0.4%)
National	23148	323(1.7%)	11(0.02%)	16(0.04%)	181(0.8%)	704(1.8%)

Table 4: Magnitude and distribution of subclinical VAD by region, 2006, Ethiopia

Region	N	Serum retinol <0.7µmole/L; n(%;95% CI)
Afar	82	47(57.3%; 45.9%-68.2%)
Tigray	119	17(14.3%; 8.5%-21.9%)
Amhara	91	37(40.7%; 30.5%-51.5%)
Addis Ababa	99	29(29.3%; 20.6%-39.3%)
Oromiya	109	61(56.0%; 46.1%-65.5%)
SNNPR	115	13(11.3%; 6.2%-18.6%)
Benishangul-Gumuz	115	32(27.8%; 19.9%-37.0%)
Harari	136	48(35.8%; 27.3%-43.4%)
Dire Dawa	100	48(48.0%; 37.9%-58.2%)
National	996	375(37.7%; 35.6%-39.9%)

Table 5: Prevalence of Bitot's spot and subclinical VAD by sex, age and residence, 2006. Ethiopia

		Bitot's spot		Serum retinol (<0.7µmole/L)	
Sex/age	Category	N	n (%)	N	n (%)
	Male	11848	217(1.8%)	497	173(34.8%)
Sex	Female	11110	126(1.1%)	465	156(33.5%)
			p<0.05*		**NS**
	6-24	8945	55(0.6%)	192	65 (33.9%)
Age	25-48	9055	147(1.6%)	376	128 (34.0%)
	49-72	4960	141(2.8%)	397	139 (35.0%)
			p<0.05		**NS**
Residence	Predominantly urban	7480	90(1.2%)	335	91(27.2%)
	Predominantly rural	15668	235(1.5%)	631	156(24.7%)
			p<0.05		**NS**

**based on chi squared statistic; NS: Not significant*

Annex 5: Manuscripts 2: Demographic and Health Related Risk Factors of Subclincal Vitamin A Deficiency In Ethiopia

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ABSTRACT

The study was conducted to determine the demographic and health related risk factors of subclinical vitamin A deficiency in Ethiopia. Blood samples were collected from 996 children in 210 clusters across the nation for serum retinol analysis. Interviews were conducted with the respective mothers of the 996 children on presumed risk factors of vitamin A deficiency. A higher subclinical vitamin A deficiency is associated with, not receiving vitamin A supplement over the year, having been ill during the two weeks preceding the survey, no or incomplete vaccination, belonging to a mother with high parity and low levels of awareness about vitamin A. Moreover, being from Muslim household was strongly associated with higher subclinical vitamin A deficiency levels. Among the risk factors identified, low levels of vaccination, high parity and low levels of maternal awareness about vitamin A appear to have contributed to higher risks of vitamin A deficiency among Muslim children. The findings underscore the need for strengthened awareness creation regarding family planning and importance of vitamin A, promotion of vaccination and child health, intensification of vitamin A supplementation and in-depth investigation on factors contributing to increased vulnerability of Muslim children.

Key words: serum retinol, subclinical VAD, magnitude, risk factors, Ethiopia

INTRODUCTION

The far-reaching health consequence of vitamin A deficiency (VAD) is well substantiated by numerous well designed scientific studies (1, 2). Meta analysis of a number of trials have clearly demonstrated that as much as 23% reduction in mortality rates of children could be achieved by improving vitamin A status (3). Several studies in the past and present have established that VAD is a major public health problem in Ethiopia (4- 10). Except in the Southern region where studies have consistently shown low levels of vitamin A deficiency (4, 10) the problem has continued to constitute a major public health concern in other regions. In some regions, close to 8% prevalence rate of bitot's spot (clinical vitamin A deficiency) was reported, perhaps the highest rate ever recorded in the world (6). The fifth nutrition situation report of the United Nations, Standing Committee on Nutrition, indicates that the prevalence of xerophthalmia in Ethiopia is the highest in the world (11).

Cognizant of the wide-scale prevalence and enormous health impacts, interventions were initiated as early as 1960th in Ethiopia. During 1969-1973, a pilot intervention study in two towns (one with nutrition education and the other with vitamin A capsule distribution) emphasized the value of these interventions and following this, disease-targeted vitamin A supplementation along with nutrition education were initiated. The nationwide vitamin A supplementation began in 1995 as a component part of EPI (Extended Program on Immunization) and starting from 1997, vitamin A supplementation was effected through campaigns either integrated with the National Immunization Days or a stand-alone activity. Initially the coverage was good, but later, the coverage dropped substantially, as a result of the deaths that occurred during the supplementation. While squeezing the contents of the capsule during oral dosing, in some rare instances the entire capsules slipped in to the mouths of the children and choked them by sticking to esophagus and blocking air passage. At the time of this survey, Enhanced Outreach Strategy, incorporating deworming and other health interventions along with vitamin A supplementation was being implemented in three regions.

The primary cause of VAD is inadequate dietary consumption of vitamin A and or sub-optimal utilization of the nutrient in the body. A number of secondary factors are known to contribute towards insufficient dietary intake of vitamin A. Inadequate production of vitamin A rich foods, lack of income to purchase, unavailability of vitamin A rich foods in the markets, large family sizes, high maternal parity levels, low level of maternal education, low levels of awareness about the importance of vitamin A and illness are some of the secondary factors that are presumed to contribute to inadequate consumption of vitamin A in developing countries.

As the risk factors and determinants of vitamin A are context specific (socioeconomic, cultural, environmental etc) variations in factors contributing to VAD exist among countries, regions and localities, underlining the need to assess country/region/area specific risk factors. Knowledge on such specific risk factors enables implementers and policy makers to design and implement effective interventions. Unfortunately, studies related to country, region area specific causes of vitamin A in Ethiopia are scarce and hence, substantive information regarding factors contributing to VAD is lacking. The aim of this study is to partially fill the information gap on causes of VAD by providing information on some demographic and health related risk factors.

MATERIALS AND METHODS

Survey design and sampling

Multi-stage, cluster-sampling approach and cross-sectional study design were employed in the study. Out of the eleven regional administrative states that constitute the Federal Government of Ethiopia, nine were included in the survey (two regions were excluded due to security reasons). In each region, 30 clusters (villages) were randomly selected and blood samples were collected from five systematically selected children, bringing the regional sample size to 150 children and national to 1350 children (nine regions). The sample size of 150 children per region was determined based on 44% prevalence rate of deficient serum retinol levels reported in the 1980/81 national study, p=44%, 95% confidence interval, error margin of 10.0% and clustering effect of 1.5. Interviews pertaining to household, maternal and child characteristics presumed to contribute to vitamin A deficiency were conducted with the mothers of the children included in the biochemical assessment. In the final analysis, the serum retinol results of 996 children (due to insufficient blood for the analysis) and corresponding maternal interviews were used.

Data collection

Lab technicians trained by experienced senior lab technicians collected blood samples. All necessary safety measures were strictly maintained during blood collection. Blood samples were kept in icebox and in dark place until they were transported to health institutions where centrifuges and refrigerators were available. After centrifuging, the sera were kept in deep freezer below -80 Degree Celsius. Analysis of serum retinol was performed at Ethiopian Health and Nutrition Research Institute using High Performance Liquid Chromatography (12).

Ethical approval was obtained from the Research and Ethical Clearance Committee at the National Health and Nutrition Research Institute. Following thorough explanations about the importance of the survey, family's consent was requested. Blood collection ensued only when the consent of the family was obtained. At the end of blood sample collection, *biscuits and soaps* were given to the children as incentives.

Trained data collectors administered the household questionnaire. Three days thorough theoretical and practical training was given to the data collectors. Data collection commenced only when common understanding among all data collectors was reached.

Data processing and analysis

Age of the children was categorized as 6-24 months, 25-48 months and 49-72 months. The age of mothers was categorized as below 25 years, 25-35 years and above 35 years. The education level of mothers was categorized as 'illiterate' when the mother can't read/write and 'literate' when the mother reads/writes or has gone to formal school. The overall knowledge of mothers regarding vitamin A refers to knowing or not knowing at least one aspect of vitamin A, (consequences or foods rich or the importance). Similarly, overall illness refers to being ill over 15 days preceding the survey regardless of types, episode and severity of the illness. World Health organization (WHO) recommends serum retinol levels <0.7μmole/lt as a cut off point indicative of the presence of subclinical vitamin A deficiency. (12). This cut-off point was used in this study.

Serum retinol results and the data collected through the interview were entered in Statistical Package for Social Studies (SPSS) statistical software and analysis was done on the same software. Bi-variate logistic regression was used to examine the strength of the association of each variable to vitamin A (without controlling the effect of other variables). Multivariate logistic regression was used to examine the independent, collective and individual contributions of child, maternal and household attributes. Three models were constructed. The first model contains only child characteristics; the second model contains child and maternal characteristics and the third model (full model) child, maternal and household characteristics.

RESULTS

Prevalence of subclinical vitamin A deficiency by child related risk factors is presented in Table 1. The results of the bivariate analysis indicate that the prevalence of subclinical vitamin A deficiency was not markedly different between female and male children. Neither significant difference nor discernable trend in subclinical VAD was observed among children in the three age categories. However, the prevalence rate of subclinical VAD was significantly higher among children who did not complete vaccination compared with those who have completed, among children who were ill in the fifteen days prior to survey compared with those who were not and among those who did not receive vitamin A supplement at least once over the year compared with those who had received.

The prevalence of subclinical vitamin A deficiency by household and maternal characteristics is shown in Table 2. The bivariate results show lack of significant difference in the prevalence of subclinical vitamin A deficiency among rural and urban children. The prevalence of subclinical vitamin A deficiency is modestly but significantly higher among children belonging to large-sized households (six and more members) and more under five siblings (two or more) compared with children belonging to small-sized households (five and less) and few under five siblings (one or none). The prevalence of subclinical vitamin A deficiency among Muslim children is significantly higher than the prevalence of subclinical vitamin A deficiency compared with the prevalence among Christian children.

There is no difference in the prevalence of subclinical vitamin A deficiency among children born to older, middle age and younger mothers. However, the prevalence of subclinical vitamin A deficiency is significantly higher among children whose mothers had more deliveries (three and above), children belonging to illiterate mothers and children belonging to mothers who have low levels of awareness about vitamin compared to children whose mothers have a few deliveries (two and below), children belonging to literate mothers and children belonging to mothers who have better awareness about vitamin A.

The result of multivariate logistic analysis is presented in Table 3. Among the child attributes, (model I) vitamin A supplementation at least once over the year, illness over two weeks prior to the survey and vaccination status of the children were found to be significantly associated with subclinical vitamin A deficiency. Among the combined child and maternal variables (model II), the child attributes that were significant in model I, parity and awareness about vitamin A from the maternal attributes were found to be significantly associated with subclinical vitamin A deficiency. While all the maternal and child related attributes that were significant in Model II persisted to be significantly associated (model III), only religion was strongly and significantly associated with subclinical vitamin A deficiency from the household characteristics.

The likelihood ratio associated with the full model (model III) is 80.94; p=0.000. Out of this total likelihood ratio, child related attributes (VAS, illness and vaccination status) contributed only 19.39 (23.96), maternal characteristics (parity, maternal awareness about vitamin A) contributed 26.58 (32.84%) and household characteristics (religion) contributed 34.98 (43.22%), indicating that while maternal and child related attributes constitute modest risks, religion constituted the single most important risk to subclinical vitamin A deficiency among children in Ethiopia.

The result of the comparison of the identified risk factors among Muslim and Christian children is presented in Table 4. The proportion of Muslim children who have completed vaccination is significantly lower than the proportion of Christian children who have completed vaccination. The proportion of Muslim children belonging to, large family sized households, mothers with more births, illiterate mothers and to mothers with low levels of awareness about of vitamin A are significantly higher compared with children from Christian households.

DISCUSSIONS

The fact that vitamin A deficiency is strongly associated with disease is well substantiated. Studies have clearly shown that diarrheal disease affects vitamin A status by substantially increasing nutrient loss (3). Similarly, intestinal parasites (giardia, ascaris and hookworm) reduce the absorption of nutrients. Studies also indicate that respiratory tract infections compromise the dietary absorption (13, 14). The substantial contribution of childhood illness to VAD is corroborated by the findings of this study. In addition, the importance of immunization in preventing childhood illness and vitamin A deficiency is highlighted by the findings of this study. The study also confirmed the fact that Vitamin A supplementation is an efficient intervention to prevent and control vitamin A deficiency.

Parity is one of demographic characteristics presumed to affect nutritional status of mothers and children. Repeated and short spaced deliveries are known to deplete nutrients, compromising the capacity of mothers to adequately nourish their children. This assertion is supported by the findings of this study. Maternal education status and maternal knowledge about nutrition and specific nutrients are believed to play a substantial role on nutritional status of children. Although, maternal education categorized as 'illiterate' and 'literate' showed no association with the subclinical vitamin A deficiency, the knowledge of the mother regarding vitamin A has shown a strong association with subclinical vitamin A.

The findings of the study regarding the low contributions of child attributes, and the modest contributions of maternal attributes and the high contributions of household attributes (religion) to the variations in subclinical VAD suggest that factors that appear to be distantly related to vitamin A deficiency can constitute a major risk to vitamin A deficiency. The finding highlights the potential synergetic impact of interventions that simultaneously address the child, maternal and household related risk factors.

Differences in nutritional status between the Muslim and Christian households have been reported in other studies. For example, findings of a study on nutritional status of mothers in Hadiya zone, indicated that Muslim women were more malnourished compared with Christian women (15). Similarly the national study conducted in 1980/81 documented a significant difference in clinical vitamin A deficiency among Muslim and Christian children (4). Obviously, religion per se could not be implicated as a cause affecting vitamin A status in particular and nutritional status in general. Religion exerts impacts through its influence in socioeconomic status, education, health and nutritional practices. Therefore, the difference in vitamin A status between Muslim children and Christian children is obviously due to the difference in other immediate and underlying causes. Although it was not supported by statistical analysis, the national vitamin A survey of 1980/81 implicated large family sizes of Muslim households, (as a result of having more wives), as a possible explanation for the increased prevalence of vitamin A deficiency among Muslim children. Although significant differences in household size and education levels of mothers between Muslim and Christian children were observed, the contributions of these attributes to the observed variation in subclinical VAD may not be substantial, because family size and education levels of the mothers were not associated with subclinical VAD in this study. However, the significant variation in the vaccination status of children, parity levels of the mothers and awareness about vitamin A (variables identified as risk factors to VAD) can be implicated as some of the most likely factors contributing to the significant variations in clinical VAD between Muslim and Christian children. However, in-depth studies are needed to elucidate the reasons why Muslim children are more at risk

Lack of information pertaining to socioeconomic status and dietary consumption of vitamin A, is one the major limitations of the study (these information were not collected as a result of time and budget constraints). Information on socioeconomic status and dietary consumption would have provided more insights on the risk factors. Moreover the information on these attributes could have provided more explanation about the difference in the vitamin A status between Muslim and Christian children.

In conclusion, the study revealed that Muslim children are more vulnerable to vitamin A deficiency underlining the need to further investigate the reasons. Vitamin A supplementation has shown marked positive impact on Vitamin A status and therefore must be strengthened and intensified. The study revealed pronounced negative impacts of disease and incompletion of vaccination calling for intensification of efforts related to enhancing child health and vaccination. The risk associated with increased parity levels and lack of awareness about vitamin A is highlighted, urging for strengthened awareness creation/promotion activities regarding family planning and the importance of vitamin A. The modest associations of maternal attributes and the strong association of household characteristics (religion) to subclinical vitamin A deficiency, underlines the need to address these factors along with child related factors.

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Table 1: Prevalence of subclinical vitamin A deficiency by child characteristics, Ethiopia.

Variable	Category	N (%)	Deficient (%)	Significance
Sex	Female	465(48.3)	156 (33.5)	
N=962	Male	497(51.7)	173(34.8)	**NS**
Age	24 months and below	192(19.9)	65(33.9)	
N=960	25 to 48 months	376(39.0)	128(34.0)	**NS**
	49 to 72 months	397(41.1)	139(35.0)	
Vaccination	Not at all/incomplete	468(48.4)	184(39.3)	
status (N=966)	complete	498(51.6)	148(29.7)	**p<0.05**
VAS[¶] last year	Received at least once	369(38.2)	104(28.2)	**p<0.05**
	Not at all received	597(61.8)	228(38.2)	
Overall illness	None	513(53.1%)	160(31.2%)	
N=955	At least one illness	453(46.9%)	172(38.0%)	**p<0.05**

VAS[¶] = Vitamin A Supplementation

NS= not significant

Table 2: Household and maternal characteristics by prevalence of subclinical vitamin A deficiency, Ethiopia.

Variable	Category	N (%)	Deficient	Significance
Residence	Rural	631(65.3%)	207(32.8%)	
(N=966)	Urban	335 (34.7%)	125 (37.3%)	**NS**
Religion	Christian	581(60.1)	149(25.6)	
(N=949)	Muslim	385(39.9)	183(47.5)	**p<0.05**
Household size	Five and below	559(57.9)	177(31.7)	
(N=965)	Six and above	406(42.1)	155(38.2)	**p<0.05**
Under five size	One or none	500(51.8)	152(30.4)	
(N=966)	Two and above	466(48.2)	180(38.6)	**p<0.05**
Literacy status of	Illiterate	588(60.9)	220(37.4)	
mother (N=966)	Literate	378(39.9)	112(29.6)	**p<0.05**
Parity	Two and below	407(41.1)	119(29.2)	
(N=957)	Three and above	559(57.9)	213(38.1)	**p<0.05**
Knowledge about	Not at all	761(78.8)	284(37.3)	
VA (N=960)	At least one fact	205(21.2)	48(23.4)	**p<0.05**
Age of the mother	24 years or below	246 (25.6)	89 (36.2)	
(N=960)	25 to 35 years	587 (61.1)	198 (33.7)	**NS**
	Above 35	127 (13.2)	43 (33.9)	

NS= not significant

Table 3: Risk factors contributing to vitamin A deficiency in Ethiopia; adjusted OR† (95% CI)

Variables	Categories	n	Model I	Model II	Model III
Religion	Christian	581	--	--	I
	Muslim	385			2.23(1.63-3.06)
Residence	Urban	335	--	--	I
	Rural	631			0.82(0.60- 1.14)
Family size	≤5 'small	559	--	--	I
	≥6 'large	406			1.08 (0.78-1.53)
# of <5 children	<2 children	500	--	--	I
	≥2 children	466			1.15(0.85-1.55)
Maternal age	≤24 years	246	--	I	I
	25-≤35 years	587		0.75(0.53-1.06)	0.80 (0.60-1.14)
	>35 years	127		0.60(0.36-1.18)	0.72 (0.43-1.22)
Maternal literacy	literate	378	--	I	I
	illiterate	588		1.10(0.81-1.50)	0.91(0.66-1.30)
Parity	≤2 births	407	--	I	I
	≥3	559		1.70(1.23-2.32)	1.46(1.02-2.09)
Knowledge about VA	At least one fact	205	--	I	I
	None	761		1.80(1.24-2.64)	1.80(1.22-2.70)
Age of the child	≤24 months	192	I	I	I
	25-≤48 months	376	1.05(0.72-1.53)	1.05(0.71-1.54)	1.12(0.76-1.66)
	≥49-71 months	397	1.07(0.73-1.55)	0.99(0.68-1.46)	1.13(0.76-1.68)
Sex	Female	465	I	I	I
	Male	497	1.10(0.84-1.44)	1.11(0.84-1.50)	1.10(0.83-1.46)
Vaccination status	Complete	498	I	I	I
	No/incomplete	468	1.74(1.30-2.35)	1.80(1.32-2.43)	1.54(1.12-2.12)
Illness	Not at all ill	513	I	I	I
	Ill at least once	453	1.40(1.06-1.83)	1.40(1.05-1.82)	1.42 (1.07-1.90)
VAS	Yes received	369	I	I	I
	Not received	597	1.43(1.10-1.99)	1.46(1.02-2.03)	1.45(1.12-2.31)
Model Likelihood ratio			19.39 (p=0.004)	45.94(p=0.000)	80.94(p=0.000)
Increase in likelihood ratio				26.58(p=0.000)	34.98(p=0.000)

CI* = Confidence Interval
OR† = Odds Ratio

Table 4: Likely factors contributing to increased risk of vitamin A deficiency among Muslim children, Ethiopia

Variable	Category	Christian	Muslim	Significance*
Household size	≤5 'small'	366(63.0%)	193(50.3%)	P<0.001
(N=965)	≥6 'large'	215(37.0%)	191(49.7%)	
Literacy status of the	Unable to read/write	299(51.5%)	289(75.1%)	P<0.001
mother (N=966)	Literate	282(48.5%)	96(24.9%)	
Parity (N=957)	Two and below	271(46.6%)	136(35.3%)	P<0.001
(N=966)	Three and above	310(53.4%)	249(64.7%)	
Knowledge about VA	None of the aspects	435(74.9%)	326(84.7%)	P<0.001
(N=966)	At least one aspect	146(25.1%)	59(15.3%)	
Vaccination	Complete	333(54.3%)	165(42.9%)	P<0.001
(N=966)	Not at all/incomplete	248(42.7%)	220(57.1%)	
Illness	Not ill over the 15 days	308(53.0%)	205(53.2%)	NS
(N=966)	Ill over the 15 days	273(47.0%)	180(46.8%)	
Vitamin A supplementation	Has taken at least once over the year	233(40.1%)	166(43.1%)	NS
	Has not taken at all	348(59.9%)	219(56.9%)	

Significance* is based on Chi square statistic

Annex 6: Manuscripts 3: Risk factors associated with clinical vitamin A deficiency among primary school children In Arsi Zone, Ethiopia

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ABSTRACT

The study was conducted to identify the risk factors associated with clinical vitamin A deficiency among primary school students in Arsi Administrative Zone in Ethiopia. A total of 3500 students in all primary schools in Arsi Zone were examined for bitot's spot and interviewed about the signs and symptoms of night blindness. Ninety seven clinical cases were identified, and for each of the cases, two controls, matched by sex, age and grade were recruited. Retrospective information on the potential risk factors was collected using structured questionnaire. Being from Muslim household, inadequate consumption of vegetables and illness in the two weeks preceding the survey were found to be strong predictors of vitamin A deficiency among the students. The socio-economic proxy variables, such as owning radio, roof type and education levels of parents as well as consumption of fruits and foods from livestock source were not associated with vitamin A deficiency. The findings underscore the need for strengthening efforts to promote vegetable consumption and improving the health conditions of the students as well as the need for in-depth investigation regarding the reasons why students from Muslim household are more vulnerable to vitamin A deficiency.

Key words: Students, Clinical VAD, Risk factors, Ethiopia

INTRODUCTION

Vitamin A plays a pivotal role in prevention of infections and maintenance of the health of the ocular system. Studies have clearly demonstrated that vitamin A deficiency increases mortality rates of children by as much as 23% (1) and maternal mortality by as much as 40% (2). Moreover, the contribution of vitamin A deficiency to the high prevalence of blindness in developing countries is a well established fact (3).

Several studies have consistently indicated that vitamin A deficiency is one of the major health problems among preschool children in Ethiopia (4- 9). While the extension of the problem to school age children, especially among the lower primary school students, is indisputable fact, little has been done in terms of research or interventions in Ethiopia. As the focus and attention has been inclined towards the preschool children, health and nutrition of the school children has been largely overlooked. Recently, however, the health and nutrition of the school age children is receiving attention by a multitude of stakeholders, as a result of increasing empirical evidence highlighting the enormous benefits of optimal health and nutrition on education outcomes (10, 11, 12). As an initial step in this accord, a comprehensive national school health and nutrition survey was conducted in 2007 by Save USA, Ethiopia, (13) and based on the findings of the study; school health and nutrition strategy is being formulated currently.

The national survey revealed that vitamin A deficiency is also a common nutritional problem among school children. The survey indicated that the overall prevalence of reported night blindness was 12.8% (95% CI 11.3, 14.3) and that the prevalence of night blindness was over 10% in six regions out of the 11 regions in Ethiopia. The survey also showed that nationally, close to 1% of the students had bitot's spot (13). Apart from the national study, a study, probably the only study that has included biochemical indicators, regarding vitamin A status of school children in Northern Ethiopia (14) showed a 5.8% prevalence rate of xerophthalmia, 8.4% prevalence rate of deficient serum retinol levels (below 0.35 µmole/L) and 51.1% prevalence rate of low levels of serum retinol levels (between 0.35 and 0.70 µmole/L).

It appears that while some information on the magnitude and distribution of VAD among primary students is existing, the information on factors contributing to vitamin A deficiency among school children is unavailable or scanty in Ethiopia. However, the usual monotonous diets such as cereal-legume (injera and wot) and livestock-cereal diets and the wide spread childhood illness, inadequate consumption of vitamin A rich foods can be implicated as the main causes of VAD among school age children in Ethiopia. The national school health and nutrition survey indicated that only 23.8%, 26.3% and 16.5% reported to have eaten fruits, vegetables and meat respectively over the past 24 hours (13).

In the Ethiopian context, a number of factors could be speculated to play substantial role towards inadequate consumption of the nutrient. The cultivation/production practice of vitamin A rich foods, such as, fruits, vegetables and livestock foods is negligible. Lack of income and/or unavailability of vitamin A rich foods in markets could also be regarded as one of the contributing factors towards vitamin A deficiency. A number of socio-economic, demographic and cultural factors could also be tagged to vitamin A deficiency, such as the large family sizes, high maternal parity levels, the low level of parental education, the low level of awareness about the importance of vitamin A in the well-being of the children.

It is well established that disease plays a substantial role in increasing the vulnerability of children to vitamin A deficiency. Disease predisposes children to VAD by reducing the utilization of the vitamin A in the body. Studies have clearly shown that intestinal parasites, diarrheal disease and respiratory tract infections affect vitamin A status by substantially increasing the nutrient loss (15, 16). The national school health and nutrition survey indicated that nationally, 29.8% of the students were infested by intestinal parasites. Thus, the widely occurring diseases in Ethiopia appear to have exacerbated VAD (13).

In order to systematically and effectively address vitamin A deficiency among school children, up-to-date and reliable information on the risk factors is needed. However, as noted above, apart from presumptive and speculative opinions, substantive information on the potential risk factors predisposing school children to vitamin A deficiency is lacking in Ethiopia. The aim of this study is to fill this information gap, by identifying potential risk factors, by employing case-control study design.

MATERIALS AND METHODS

Site selection

Vitamin A deficiency surveys have consistently indicated that vitamin A deficiency is serious in the Arsi Zone, Oromiya region, Ethiopia. A prevalence of 11% bitot's spot among preschool age children was recorded in 1993 (17) that required mass treatment to mitigate the impact of the problem. With the assumption that school age children also suffer from vitamin A deficiency (because school children share everything with the under-fives in a community), Arsi Zone was selected for the study.

Definition and recruitment of cases and controls

Cases were defined as school children in grades 3 and 4 who had confirmed clinical signs (bitot's spot's and corneal ulcerations) or confirmed night blindness. Among the students free of the clinical signs, controls were recruited, matched by grade, age and sex. The presence of clinical signs was confirmed and a student was considered a case, only when the judgments of the ophthalmologist nurse and that of the senior nutritionist agreed. In the confirmation of night blindness, a number of questions related to the condition were asked, such as whether the student knows what night blindness means, whether he/she bumps in to things at dusk, whether other children in the house have the same problem, whether he/she has difficulty in seeing at day time, whether he/she is forbidden to roam around in the house during dusk, whether he/she has been harassed or insulted. In addition, the frequency of consumption of fruits, vegetables and livestock products was assessed.

Sample size determination

For the purpose of estimating the sample size for the case-control study, frequency of consumption of vegetables, the proximate risk factor to vitamin A deficiency in rural Ethiopia, was considered. The recent results from the national survey suggest that about 53% of rural children do not consume dark green vegetables adequately (18). A study has also shown that children who are not fed vegetables daily or every other day (three times or more in a week) were more than 2 times at risk of being affected by vitamin A deficiency compared to children who are fed at least every other day (19). These information were used to estimate the sample size required per group. Thus, using minimum expected OR = 2; frequency of those who do not consume adequately among controls =53%, confidence level = 95%; power = 80% and case–control ratio of 1:2, and applying the EPI-INFO 2000 formula (20), a sample size of 114 cases and 228 controls were obtained. However, 97 cases and 194 controls were included in the study due to various difficulties. All the cases were treated with 200,000 IU vitamin A and incentives of biscuits and soap were given.

Data collection on risk factors

Retrospective information on the potential risk factors was gathered using a structured questionnaire. These included; demographic and socio-economic characteristics of the families of the students, type and frequency of consumption of vegetables, fruits and livestock products, morbidity status over 15 days prior to the survey and knowledge regarding various aspects of vitamin A.

The questionnaire was administered by five trained data collectors. The criteria of selection of data collectors included; high school completion, experience in data collection and fluency in local language. In order to standardize the data collection, three days thorough theoretical and practical training was given.

Data management

SPSS statistical software was used for the data entry, cleaning, data processing and analysis (90). An experienced data entry clerk was employed for this purpose and thorough data cleaning followed data entry. Age of the children was categorized as '8-10 years' and '11-15 years'. The overall knowledge of the students regarding vitamin A refers to 'knowing' or 'not knowing' at least one aspect of vitamin A, (consequences or foods rich or the importance). Similarly, overall illness refers to being ill regardless of types, episode and severity of the illness. In night blindness, those who reported having problems in daytime vision were excluded. The data entered and cleaned in SPSS was then converted to STATA version 7 and bivariate conditional logistic regression (to examine the association of each factor to the disease) and multivariate conditional logistic regression (to determine the level of independent contributions of presumed risk factor) were run. Only factors that showed significant associations in the bivariate analysis, were entered in to the model.

RESULTS

As shown in Table 1, the age of the students enrolled in the study ranged from 8-15 years. Although insignificant, more students were enrolled from the age category of 8-10 years compared with 11-15 years. However, significantly more male students were enrolled in the study compared to female students ($p<0.001$). Similarly, significantly more rural students were included in the study compared to urban ($p<0.001$), while the difference in the enrollment from grades three and four was not that significant.

Socio-demographic characteristics of the primary school students by VAD status is presented in Table 2. Significantly more households of the controls had functional radio compared to households of cases. More cases belong to Muslim families whereas more controls belonged to Christian households (P<0.001). The results of bivariate conditional logistic regression analysis indicated that the probability of the cases to have a functional radio and to belong to Christian households are 2.09 and 5.88 times less compared to that of the controls, respectively. There was no significant difference in roof types, household sizes, educational status of fathers and mothers between cases and controls.

Fifteen days morbidity status of the students is presented in Table 3. The proportion of children who reported to have been sick due to respiratory tract infections over the two weeks period prior to the survey was not that different among cases and controls. However, the proportion of students who reported to have had stomach problems, diarrhea and malaria plus other illnesses was significantly higher among cases compared with that of controls. The results of bivariate conditional logistic regression analysis indicated that the probability of the cases to have had diarrhea, stomach problems and at least one of the illnesses were 3.26, 2.20 and 2.71 times higher compared to that of the controls, respectively.

The proportion of cases who reported to have consumed vegetables and fruits three or more times in the week preceding the survey was significantly lower compared with the proportions among the controls (Table 4). Similarly, the proportion of cases who have reported to have consumed animal foods at least once over the week was significantly lower than the proportion among the controls. The results of bivariate conditional logistic regression analysis indicated that the odds of cases in consuming inadequate vegetables, fruits and animal foods were 4.10, 2.42 and 2.72 times higher compared to that of the controls, respectively.

Multiple conditional logistic regression was run to identify the net contribution of potential risk factors (factors that showed significant variations between cases and controls in the bivariate analysis) to vitamin A deficiency among primary school children (Table 5). Among household characteristics, religion was found to be the strongest predictor of clinical vitamin A deficiency. Students from Muslim families were 7.03 times more at risk to vitamin A deficiency compared to students from Christian Families. Owning functional radio by the household was not associated with clinical vitamin A deficiency among primary school students. Among child characteristics, vegetable consumption was found to be the strongest predictor of clinical vitamin A deficiency. Students who did not consume vegetables adequately (three or more times) in the week preceding the survey were 3.04 times at odds of developing vitamin A deficiency compared with children who have consumed adequately. Illness in the two weeks preceding the survey was also found to be associated with vitamin A deficiency. Students who had at least one ailment over the two weeks prior to the survey were 2.04 times more at risk compared with children who were not ill. Animal food consumption and fruit consumption showed no association with clinical vitamin A deficiency among the students.

DISCUSSIONS

Although the prevalence rates estimated from the case-control studies may not be accurate, the proportion of cases to the total number of students examined in the study can provide clues about the magnitude of the problem in the area. The proportion of students who had night blindness or bitot's spot or both was about 2.7% which is about three times higher than the WHO cut off point set for night blindness and over five fold higher set for bitot's spot (22). As mentioned earlier, although these figures may not be the true estimates of the prevalence, they however, signal the seriousness of vitamin A deficiency among school age children in the area.

The number of students enrolled in the study depended on the number of cases identified. Therefore, the presence of significantly more male than female cases was most likely due to the general low enrollment rate of female students in the area. Although, the increased vulnerability of male children had been reported and can not be ruled out, such assertion can not be warranted based on this study as a result of obvious methodological limitations. The same line of argument holds true regarding the huge difference in the number of cases from urban and rural residences. Although the increased vulnerability of students from the rural settings can not be ruled out, the difference observed in this study appears to be due to difference in the number of students enrolled in urban and rural areas.

As an initial step in the process of identifying the potential risk factors, the difference/similarities pertaining to various household and student attributes between the cases and controls were examined. Previously, owning functional radio and owning iron sheet roofed houses were often used as proxy indicators of socio-economic status. Lack of difference in the ownership of these items between the households of the cases and controls, may suggest that either these items are no more a good socio-economic indicators or socio-economic attributes do not affect vitamin A status. Educational status of parents, which were implicated as contributing to child malnutrition, particularly preschool children, were not different between the parents of the cases and controls, suggesting that parental education is not that important in vitamin A status of the students. Similarly, lack of difference in household sizes of the cases and controls, suggest that these demographic attributes may not be important determinant of vitamin A deficiency.

The only attribute, among the household characteristics that significantly differed among the families of the cases and controls is religion. More children identified as cases belong to Muslim families whereas more children recruited as controls belong to Christian households. Among the students related attributes, sickness over the two weeks time prior to the survey, livestock, vegetable and fruit consumption in the week preceding the survey showed significant difference between the cases and controls.

Attributes that showed significant difference between the cases and controls were entered in to multiple conditional logistic regression model, to examine the net contribution of each attribute to vitamin A deficiency among primary school children by controlling the effect of other variables.

Even after controlling for other variables, religion stood out to be strongly associated with clinical vitamin A deficiency among students. The same high level of subclinical vitamin A deficiency rates was observed among preschool age Muslim children compared to Christian children (23). Differences in nutritional status between the Muslim and Christian households have also been reported in other studies (6,24). The difference in vitamin A status of children from Muslim and Christian households was obviously due to the difference in other immediate and underlying causes, not the religion per say.

The finding regarding the strong protective contributions vegetable consumption signifies the fact that vegetables are important sources of vitamin A in Ethiopia as elsewhere in developing countries and that the contributions of other vitamin A rich food sources particularly that of livestock is negligible. Usually even in the normal years, livestock products are only consumed during three or four festivals over the year in Ethiopia. With the sky rocketing prices of livestock products currently, the consumption of livestock products three or four times has become a luxury. Obviously, in such circumstances, the contribution of vegetables in preventing vitamin A deficiency becomes enormous.

The fact that vitamin A deficiency is strongly associated with disease is well substantiated (15,16) as described in the introduction section. The substantial contribution of illness to vitamin A deficiency is also corroborated by the findings of this study. Students who were sick two weeks prior to the survey were 2.04 times more at risk compared to children who were not ill.

In conclusion, primary school children from Muslim households were found to be more vulnerable to vitamin A deficiency, urging for in-depth studies to uncover the reasons. Vegetable consumption and illness were found to be the major determinants of vitamin A deficiency among the school children. Interventions related to promotion of the production and consumption of vegetables and improving the health conditions of students through availing health services at schools are important in improving vitamin A status of school children.

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Table 1: Age, sex, grade and residence of the students enrolled in the case control study, Arsi Zone, Ethiopia, 2007.

Variable	Category	%	Significance*
Age	8-10 years	59.8	NS
(N=291)	11-15 years	40.2	
Sex	Male	60.8	p<0.001
(N=291)	Female	39.2	
Grade	3rd	59.8	NS
(N=291)	4th	40.2	
Residence	Town	14.4	p<0.001
(N=291)	Rural village	85.6	

**based on chi squared statistic, NS: Not significant*

Table 2: Socio-demographic characteristics of cases and controls in primary schools in Arsi Zone, Ethiopia, 2007.

Exposure variable	Categories	Cases (n=97) %	Control (n=194) %	Unadjusted OR* (95% CI†)
Radio ownership	Yes (reference)	74.2	85.1	
	No	25.8	14.9	**2.09 (1.11-3.93)**
Roof type	Corrugated iron (reference)	41.2	44.3	
	Grass-thatched	58.8	55.7	1.17 (0.67-2.03)
Religion	Christian (reference)	28.9	61.9	
	Muslim	71.1	38.1	**5.88 (3.01-11.78)**
Household size	Six and below (reference)	50.5	53.6	
	Seven and above	49.5	46.4	1.14 (0.69-1.87)
Education of the mother	Literate (reference)	29.9	37.1	
	Illiterate	70.1	62.9	1.85 (0.86-3.17)
Education of the father	Literate (reference)	52.6	59.3	
	Illiterate	47.4	40.7	1.39 (0.80-2.24)

* OR = Odds Ratio

†CI= Confidence Interval

Table 3: Fifteen days morbidity status of students enrolled in the study, Arsi Zone, Ethiopia, 2007.

Variable	Category	Controls N =194 %	Cases N=97 %	Unadjusted OR* (95% CI†)
Respiratory tract infection	Yes	17.5	18.6	1.08 (0.55-2.14)
	No (reference)	82.5	81.4	
Diarrhea	Yes	5.7	15.5	**3.26 (1.38-6.80)**
	No (reference)	94.3	84.5	
Stomach problems	Yes	13.4	24.7	**2.20 (1.18-4.19)**
	No (reference)	86.6	75.3	
Malaria and others	Yes	4.6	10.3	2.97 (0.98-5.99)
	No (reference)	95.4	89.7	
At least one of the ailments	Yes	31.4	42.3	**2.71 (1.02-2.88)**
	No (reference)	68.6	57.7	

* OR = Odds Ratio; †CI= Confidence Interval

Table 4: Fruit, vegetable and animal food consumption among primary school students by VAD status in Arsi Zone, Ethiopia, 2007

Food category	Frequency of consumption over the week	Cases (n=97) %	Control (n=194) %	Unadjusted OR* (95% CI†)
Vegetable consumption	≤ 2 times	61.9	38.7	
	≥ 3 times (reference)	38.1	61.3	**4.10 (2.10-6.23)**
Fruit consumption	≤ 2 times	60.8	43.3	
	≥ 3 times (reference)	39.2	56.7	**2.42 (1.37-4.28)**
Animal food consumption	None	59.8	43.3	
	At least once (reference)	40.2	56.7	**2.72 (1.45-5.23)**

OR = Odds Ratio; †CI= Confidence Interval

Table 5: Potential determinants of clinical vitamin A deficiency among primary school students, Arsi zone, Ethiopia, 2006.

Exposure variables	Categories	Adjusted OR (95% CI)
Household ownership of functional radio	Yes	1
	No	1.70 (0.77-3.52)
Religion	Christian	1
	Muslim	**7.03 (3.30-10.92)**
At least one illness 15days prior to the survey	No	1
	Yes	**2.04(1.07-3.69)**
Vegetable consumption	≥ three times over the week	1
	≤ two times over the week	**3.04(1.47-6.17)**
Fruit consumption	≥ three times over the week	1
	≤ two times over the week	1.82(0.89-2.64)
Animal food consumption	At least one over the week	1
	None over the week	2.09(0.99-3.64)

* OR = Odds Ratio; † CI= Confidence Interval

Annex 7: Manuscripts 4: Availability and consumption of fruits and vegetables in nine regions of Ethiopia with special emphasis to vitamin A deficiency

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Abstract

Background: Vegetables and fruits are the main sources of a number of essential micronutrients, and therefore, information on availability and consumption of vegetables/fruits is vital in designing sustainable interventions to prevent micronutrient deficiencies, particularly that of vitamin A deficiency.

Objective: The objective of the study was to assess availability and consumption of fruits and vegetables in Ethiopia.

Methods: Employing, multistage cluster sampling approach, a sample of 2552 households in nine administrative regions were interviewed on availability and consumption practice of vegetables and fruits.

Results: In aggregate, 41.5% and 75.5% of households did not produce/cultivate any of the common vegetables and fruits over the year preceding the survey. The proportion of households who did not produce/cultivate vegetables was high in Addis Ababa (99.7%), Afar (94.9%), Dire Dawa (94.2%) and Tigray (86.4%). The proportion of households who did not produce/cultivate fruits was highest in Addis Ababa (100%), followed in Dire Dawa (95.3%), Afar (92.9%), Tigray (92.2%), Harari (83.3%) and Oromiya (81.8%). In the overall, 38.1% and 36.5% of the children studied did not eat vegetable and fruit in the week preceding the survey, respectively. Own production of fruits and vegetables was significantly better ($p<0.05$) in rural areas whereas their market availabilities was significantly better ($p<0.05$) in urban areas. Analysis of beta carotene contents indicated that kale and carrots contain high amounts (>4000µg/100gm), spinach, mango and papaw contain moderate amounts (500-800µg/100gm), while staple foods contain no or negligible amounts.

Conclusions: Cultivation and consumption of vegetables and fruits is extremely sub-optimal in Ethiopia, calling for strengthened efforts to promote production and consumption of fruits and vegetables.

Key words: Vegetables, fruits, own production, market availability, and consumption

INTRODUCTION

Fruits and vegetables play a number of important roles in human health and nutrition. They provide antioxidants such as vitamin A, C and E that are important in neutralizing free radicals (oxidants) known to cause cancer, cataracts, heart disease, hypertension, stroke and diabetes (1,2). Fruits and vegetables are the most important sources of vitamin A, a nutrient important for several metabolic activities in the body, in addition to its role as antioxidant. Fruits and vegetables provide foliate and potassium that are known to prevent birth defects, cancer, heart disease, hypertension and stroke. Fruits and vegetables are good sources of minerals such as iron, zinc, calcium, potassium, and phosphorus and contain ample fiber, important for digestion and bowel movements (1, 2, 3). In the overall, WHO places low fruit and vegetable consumption among its twenty risk factors in global mortality, just behind the better known killers such as tobacco use and high cholesterol levels (4)

Cognizant of these facts, FAO/WHO recommends 400 gram of fruits and vegetables per day or alternatively five servings a day; at least two servings of fruits and three servings of vegetables (5). Moreover, experts recommend consumption of fresh, frozen, dried, or canned fruits and vegetables of a variety of colors and kinds, with more emphasis to dark-green leafy vegetables and orange fruits (6, 7).

Agreeably, among several health and nutrition benefits of insuring adequate consumption of fruits and vegetables, prevention of vitamin A deficiency appears to be the most important one, especially in developing countries. Vitamin A deficiency is the major health problem predisposing children to increased risk of morbidity, mortality and disability in developing countries (8).

Several studies in the past and present have established that vitamin A deficiency is a major public health problem in Ethiopia, as elsewhere in developing countries (9-15). Although several factors are known to precipitate vitamin A deficiency, most often in synergy, inadequate consumption of the nutrient appear to outweigh all. Human beings obtain precursors of vitamin A (provitamin A) from plant sources, such as, dark green leafy vegetables, red/yellow vegetables, fruits and preformed vitamin A from animal sources such as liver, organ meat and eggs. Much of the vitamin A (provitamin A), other micronutrients and minerals in developing countries are obtained from plant sources, as livestock sources are inaccessible for most of the rural poor, reflecting the fact that micronutrient status in general and vitamin A status in particular is strongly linked to vegetables/fruits availability and consumption in developing countries. It is estimated that over 80% of vitamin A in developing countries is supplied by fruits and vegetables (8)

Thus, it is evident that sustainable improvements in vitamin A status, other micronutrients and minerals require interventions aimed at enhancing availability, access and promotion of consumption of fruits and vegetables. Households must be taught about the importance of consumption of fruits and vegetable in human health and nutrition, particularly in the growth and development of infants and children. Empowerment of communities in terms of awareness creation and technical knowledge must be strongly pursued to enable the cultivation of fruits and vegetables in their backyard gardens.

These endeavors obviously require sound and up-to-date information on the extent of market availabilities, own production/cultivation and consumption of fruits and vegetables. Literature search revealed that such information is unavailable or scanty in Ethiopia. The aim of this study, therefore, is to reinforce the ongoing efforts aimed at promoting production and consumption of fruits and vegetables by availing relevant information to policy makers and implementers. The article is based on the data collected during the national vitamin A deficiency survey conducted in 2006.

MATERIALS AND METHODS

Sample size and sampling method

The national survey on the magnitude and determinants of vitamin A deficiency conducted between February and June 2006, employed multi-stage, cluster sampling approach and cross-sectional study design. As it was intended to report the magnitude of the problem at region level, sample size was determined in consideration of this intention. Out of the 11 administrative regions, 9 regions were included in the study. Two regions (Gambela and Somali regions) were excluded due to security concerns at the time of the study.

The sample size for the clinical examination in each region was calculated using EPI INFO 2000 (16). Based on the assumptions, p[12]=1%, confidence interval= 95%, error margin = ±0.5% and design effect = 2, a sample size of about 3000 children was obtained (3000 x 9 regions = 27000 nationally). It was arbitrarily decided to interview 10% of the mothers (caretakers) of clinically examined children in each region (300 in each region and 2700 nationally) on availability, production and consumption of fruits and vegetables. Despite unprecedented problems that occurred during the survey, 95% response rate was attained.

Thirty peasant/urban dwellers associations (the smallest administrative units in Ethiopia) were selected randomly in each region. In each selected peasant/urban dwellers association one study village (cluster) was again selected randomly. The anticipated number of preschool age children in each cluster then was 100 children (3000 divided by 30 clusters) for the clinical examination and 10 mothers/caretakers of children clinically examined for interview. Households were selected systematically and included only those households who have under-six children and when there were more than one under-six children, one child was selected randomly.

Raw and cooked samples of five common vegetables and five common fruits as well as five staple foods were randomly picked in duplicates, from the markets in Addis Ababa for beta carotene analysis. Polyethylene bags were used for the collection and storage of the samples. Food samples were kept in refrigerators until analysis was done. Vitamin A contents (provitamin A) of foods was analyzed in duplicates using HPLC according to Heinonen et al method (17).

Instruments and data collection

Information on own production/cultivation (backyard gardening), market availability and consumption practices of fruits and vegetables were collected through in-depth individual interviews using a structured questionnaire. Households were asked whether they have cultivated/produced any of the common fruits and vegetables in the previous one year, whether the common vegetables and fruits were available in nearby markets in the previous one year and the number of days the index child has consumed the common vegetables and fruits in the preceding week.

Trained data collectors administered the in-depth individual questionnaire. Three days thorough theoretical and practical training was given to the data collectors. Data collection commenced only when common understanding among all data collectors was reached. Pilot survey was conducted in Arsi Zone, Dera woreda and appropriate modifications were made prior to the commencement of the actual survey. In terms of ethical concerns, the purpose of the study was explained in detail to the respondents and their consents were sought. Respondents

[12] P is the proportion of children with VAD, which was 1% in the national survey conducted in 1980/81

were interviewed only when they agreed and signed the consent forms.

Data management

The data collected through the questionnaires was entered in to SPSS statistical software by experienced data entry clerks. Households who did not produce/cultivate refer to households who did not at all produce/cultivate fruits and vegetables, even not a single seedling over the whole year. Similarly, households who did not see vegetables and fruits in the nearby markets refer to households who never saw a single fruit/ vegetable, even once over the year preceding the survey in the nearby markets. Moreover, the number of times the index child has consumed fruits and vegetables refers to consuming any amount in the week preceding the survey. Data analysis was done using SPSS statistical software. Frequencies were used to generate proportions. Proportions related to the whole sample, nine regions combined, are weighted proportions.

RESULTS

The age distribution, illiteracy rate and awareness levels of the mothers included in the study are shown in Table 1. The proportion of the middle age group women (60.9%) is higher in all regions, followed by the proportion in younger age category (27.2%). The proportion of women who can not read or write was highest in Afar region (89.4%), followed in Amhara (77.5%) and Benishangul-Gumuz (69.8%) regions. In the overall, 59.2% could not read and/or write in the nine regions studied. In the aggregate 85.5% of the studied women in nine regions did not know anything about vitamin A. Over 95.0% in Afar, 94.4% in Amhara, 91.5% in Oromiya, 90.4% in Addis Ababa, 88.9% in Benishangul-Gumuz and 85.4% in Tigray did not know a single aspect of vitamin A.

The proportion of households who did not produce/cultivate any vegetable was highest in Addis Ababa (99.7%), followed in Afar (94.9%), Dire Dawa (94.2%), Tigray (86.4%) and Harari (63.1%) regions (Table 2). In the overall, 41.5% did not produce any vegetable in nine regions studied. The proportion of households who did not produce any fruit over the year preceding the survey was highest in Addis Ababa (100%), followed in Dire Dawa (95.3%), Afar (92.9%), Tigray (92.2%), Harari (83.3%) and Oromiya (81.8%) regions. The weighted average for the nine regions was 75.5%.

Awareness about availability of common vegetables in nearby markets over the year preceding the survey indicated that high proportion of households in Afar (82.3%) did not see any of the vegetables mentioned in the nearby markets (Table 2). Most households in Afar (79.5%) and in Tigray (67.5%) reported that they have not seen any fruit in the near by markets over the year preceding the survey.

In the overall, among all the index children studied in nine regions, 38.1% did not eat any of the common vegetables (kale, spinach, cabbage, carrot, tomato and pumpkin) over the week preceding the survey (Table 3). The proportion of index children who did not eat any vegetable was high in Afar (85.0%), Tigray (77.6%), Amhara (61.8%) and Addis Ababa (59.3%) and relatively low in SNNPR[13] (7.0%), Dire Dawa (15.6%) and Oromiya (18.6%). Among all the children studied in nine regions, 36.5% did not eat any of the common fruits (mango, papaya, oranges, avocado and banana) over the week preceding the survey. The proportion of index children who did not eat fruits was high in Tigray (88.1%) and Afar (83.5%) and was relatively low in Harari. (23.3%). Comparative analysis of the situation regarding production, market availability and consumption of fruits and vegetables between predominantly urban areas (Dire Dawa, Addis Ababa and Harari) and predominantly rural areas (Amhara, SNNPR, Benishangul-Gumuz, Tigray, Oromiya and Afar) showed that significantly more rural households have produced/cultivated vegetables and fruits ($P<0.001$) compared to urban households (Table 4). In the contrary significantly more urban households ($P<0.001$) have reported that vegetable and fruits were available in the markets compared to rural households. The proportion of index children who consumed vegetables in a week prior to the survey was not different between the groups. However, the proportion of the index children who have consumed fruits was significantly higher among the urban dwellers ($P<0.001$) compared with the rural dwellers.

The result of the beta carotene analysis of common vegetables, fruits and staple foods consumed in Ethiopia is depicted in Table 5. Uncooked kale and raw carrots contain the highest amounts (5800-6100 μg/100gm) of beta-carotene, spinach, mango and papaw were found to contain relatively high amounts (500-800 μg/100gm), tomatoes and pumpkin contain modest amounts (about 200 μg/100gm), while cabbage, orange, banana, potato, and staple foods contain no or little amount (nil to 50 μg/100gm) beta-carotene.

[13] Southern Nations Nationalities and Peoples' Region

DISCUSSIONS

Although factors such as malnutrition, illnesses and unavailability of fat in the diet, contribute towards vitamin A deficiency (18,19), inadequate intake of foods containing vitamin A appears to constitute the single most important risk factor to VAD in developing countries (8). Inadequate intake of foods containing vitamin A is basically due to lack of access to vitamin A rich foods, which is a function of inadequate production, inadequate availability in the market or inability to purchase the foods.

With regards to the practice of own production/cultivation of the common vegetables and fruits, the study showed a bleak picture in Ethiopia. When the fact that the proportion of households who reported to have cultivated/produced also included those who had a single seedling/plant of a vegetable/fruit in their gardens even once over the year, it is obvious that the proportion of households who produced adequate fruits and vegetables in their gardens/homesteads is insignificant. Based on WHO recommendations suggesting unavailability of dark green leafy vegetables for more than six months in an area as indicative of increased risk to VAD (20), many regions in Ethiopia can be considered as VAD endemic. The situation in Afar, Addis Ababa, Harari, Tigray and Dire Dawa exhibits worst scenarios. Simultaneously, conducted survey on the magnitude and distribution of subclinical vitamin A deficiency indicated that the prevalence was high in these regions, suggesting a potential negative contribution of poor backyard gardening practice to vitamin A deficiency (21).

Much of the soil and climate in many parts of the country is favorable for horticulture, as evidenced by a number of ongoing investments in the sector. Lessons learned from successful urban agricultural projects in many parts of the world (22, 23), indicated that even urban households can produce adequate vegetables for household consumption. Apparently, the major impediment to own production in Ethiopia appears to be lack of awareness about the importance of fruits and vegetables in the wellbeing of children and women.

In the overall, market availability of fruits and vegetables appear to be relatively good compared to own production, but there are gaps in some regions that might need some kind of interventions. For example, market availability of fruits and vegetables is worrisome in Afar and Tigray regions and should deserve attention.

The findings regarding consumption of vegetables and fruits indicated that the practice is sub-optimal in Ethiopia. Majority of the children did not at all eat vegetable and fruit over the week preceding the survey and when the proportion of children who have eaten once or twice (inadequate consumption) is also considered, it is apparent that vegetable and fruit consumption is indeed extremely suboptimal in Ethiopia. WHO suggests that if less than 75% of preschool age children consume vitamin A rich foods at least three times a week (17), the community/population should be considered as at risk community/population and based on this suggestion, many communities in Ethiopia can be considered as 'at risk community'. The proportion of children who did not eat vegetables even once, let alone three times in a week is greater than 75% in Afar and Tigray regions. FAO estimates that Ethiopians eat less than 100 gram of fruits and vegetables/per day, a size of a medium carrot, which is less than a quarter of the recommended fruit and vegetable consumption (5, 24).

Although this study and other studies did not explore why vegetables and fruits are not widely consumed in Ethiopia, a few likely reasons can be forwarded based on the dietary habits in the country. In most parts of the country, the diets are monotonous, consisting of a cereal and legume, cereal or milk and roots/tubers with legumes/diary products. For example, injera (thin bread made up of flour of a cereal known as 'teff') and wot (sauce of lentils, pea, beans) is the monotonous diet in the north and in towns, while sorghum/maize/wheat bread or porridge and milk are the common foods in the lowlands. Moreover, there is wrong perception by most of the population that the monotonous diet is adequate and superior to vegetables. The results of the analysis of vitamin A content of foods, however, clearly indicated that vitamin A content of teff and injera, wheat bread and 'kocho' is close to nil. While the content in shiro wot is relatively better vis-à-vis other staple foods, it is insignificant compared to beta carotene content in some vegetables and fruits. The relatively high levels of beta carotene in shiro wot compared to the shiro flour (flour of pea) appears to be due to the ingredients added to the sauce such as pepper and tomatoes.

Comparisons of the beta carotene contents of common vegetables, fruits and staple foods obtained in this study and beta carotene contents reported in the Ethiopian Food Composition Tables showed some variations. The values in the Composition Table appear to be considerably underestimated. This is anticipated because analytical procedures were different. The analysis that generated the values in Food Composition Table used open column chromatography for extraction and spectrophotometer for quantification, while HPLC was used for both extraction and quantification in this study. This finding suggests that revising the food composition tables using the more sensitive HPLC methods might be needed.

Comparisons of own production, market availability and consumption practice of fruits and vegetables between predominantly urban community and predominantly rural community yielded expected results. The situation regarding homestead gardening is relatively better among rural population, while market availability of both fruits and vegetables as well as consumption of fruits were better in urban areas. This calls for strengthened efforts to promote urban agriculture in towns and to strengthen efforts to enhance availability and consumption of fruits and vegetables in rural areas.

As reiterated elsewhere, the study was limited in some aspects. One of the limitations of the study is related to lack of data on the actual quantities of the vegetables and fruits produced by the households and consumed by the children. In surveys as big as this one, constrained by human resource, budget and time, collecting data on quantities proved difficult. As a result of lack of information on actual quantities, examination of the association of household's production, availability and consumption of fruits and vegetables with vitamin A status of children could not be done.

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Table 1: Age, education status and knowledge of mothers included in the study by region, Ethiopia, 2006.

Region	N	Age			Can't read/write	Not known a single aspect of VA
		≤24	>24-35	>35		
Afar	254	23.5%	59.8%	16.7%	89.4%	95.2%
Tigray	295	31.1%	54.3%	14.7%	59.7%	85.4%
Amhara	267	21.5%	64.5%	14.0%	77.5%	94.4%
Addis Ababa	354	31.9%	60.4%	7.7%	28.8%	90.4%
Oromiya	236	31.5%	55.7%	12.8%	44.9%	91.5%
SNNPR*	284	24.7%	68.2%	7.1%	64.4%	62.2%
Benishangul-Gumuz	300	35.4%	55.6%	9.1%	69.8%	88.9%
Harari	287	34.6%	58.2%	7.2%	50.2%	64.3%
Dire Dawa	275	31.0%	61.2%	7.8%	45.4%	71.9%
Nine regions	2552	27.2%	60.9%	11.8%	59.2%	85.5%

***SNNPR = Southern Nations Nationalities and Peoples' Region**

Table 2: Own production/cultivation and market availability situation of vegetables and fruits over the year preceding the survey by region, Ethiopia, 2006.

Region	N	Production/cultivation		Market availability	
		Not cultivated any Vegetable	Not cultivated any fruit	Not seen any vegetable	Not seen any fruits
Afar	254	94.9%	92.9%	82.3%	79.5%
Tigray	295	86.4%	92.2%	15.6%	67.5%
Amhara	267	29.2%	75.3%	3.4%	18.0%
Addis Ababa	354	99.7%	100%	0.8%	0.8%
Oromiya	236	50.0%	81.8%	2.1%	14.8%
SNNPR	284	11.6%	55.3%	8.1%	10.6%
Benishangul-Gumuz	300	25.3%	55.0%	1.7%	7.3%
Harari	287	63.1%	83.3%	20.9%	13.9%
Dire Dawa	275	94.2%	95.3%	11.3%	11.3%
Nine regions	2552	41.5%†	75.5%†	15.4%†	24.0%†

† **nine regions proportions are weighted proportions**

***SNNPR = Southern Nations Nationalities and Peoples' Region**

Table 3: Proportion of children who did not eat any of the common vegetables and fruits over the week preceding the survey by region, Ethiopia, 2006.

Region	N	Vegetables	Fruits
Afar	254	85.0%	83.5%
Tigray	295	77.6%	88.1%
Amhara	267	61.8%	30.3%
Addis Ababa	354	59.3%	33.9%
Oromiya	236	18.6%	28.0%
SNNPR	284	7.0%	35.2%
Benishangul-Gumuz	300	38.3%	41.3%
Harari	287	35.5%	23.3%
Dire Dawa	275	15.6%	31.6%
Nine regions	2552	38.1%†	36.5%†

† *nine* regions proportions are weighted proportions

***SNNPR = Southern Nations Nationalities and Peoples' Region**

Table 4: Production, availability and consumption of common vegetables and fruits by residence, 2006, Ethiopia

Attribute	Response	Predominantly urban (n=916) %	Predominantly rural (n=1630) %	Significance*
Vegetable production	No	86.6	49.1	P<0.001
	Yes	13.4	50.9	
Fruit production	No	93.3	75.1	P<0.001
	Yes	6.7	24.9	
Vegetable availability	No	10.3	18.2	P<0.001
	Yes	89.7	81.8	
Fruit availability	No	8.1	33.0	P<0.001
	Yes	91.9	67.0	
Vegetable consumption	No	39.0	38.0	NS
	Yes	61.0	62.0	
Fruit consumption	No	30.0	40.1	P<0.001
	Yes	70.0	59.9	

***based on chi square statistic**

NS=Not Significant

Table 5: β-Carotene contents of the common vegetables, fruits and some staple foods consumed in Ethiopia, 2006.

Vegetables and fruits			Staple foods		
Type	μg/100gm	EFCT* values (μg/100gm)	Type	μg/100 gm)	EFCT* values (μg/100gm)
Kale (raw)	6100.45	2330	Injera	B.D.L*	B.D.L
Kale (cooked)	4400.08	11.25	Teff flour	B.D.L	B.D.L
Carrot (raw)	5800.09	4780	Shiro wot	600.21	684
Carrot (cooked)	4300.30	1.15	Shiro flour	100.60	Trace[l]
Spinach (Raw)	800.12	3.06	Wheat flour	27.17	0.16
Spinach (cooked)	500.18	2.19	Bread	5.98	0.09
Cabbage (raw)	46.97	0.09	Potato (raw)	4.67	B.D.L
Cabbage(cooked)	12.47	0.04	Potato (boiled)	B.D.L	B.D.L
Orange	65.69	0.8	Kocho (Raw)	B.D.L	B.D.L
Banana	58.72	B.D.L*	Kocho (Baked)	B.D.L	B.D.L
Mango	500.54	B.D.L			
Avocado	B.D.L	B.D.L			
Pawpaw	800.86	0.04			
Tomato (raw)	200.29	620			
Pumpkin (raw)	200.63	280			

EFCT* = Ethiopian Food Composition Tables
B.D.L* = Below Detectable Levels
Trace[l] = some beta carotene activity