POTENTIAL OF SWEET POTATO TO INCREASE VITAMIN A INTAKE BY CHILDREN 25-60 MONTHS OLD IN RUMURUTI DIVISION, LAIKIPIA DISTRICT OF KENYA

JEDIDAH WANJIKU KIHARASON
BSc. (FND)

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Declaration

I, Jedidah W. Kiharason, hereby declare that this dissertation is my original work and has not been presented for a degree in any other university.

....

Jedidah Wanjiku Kiharason Date...20th Sep. 2010...

This dissertation has been submitted for examination with our approval as university supervisors:

....

Prof. Jasper K.Imungi, Date...20th Sept 2010...

Department of Food Science, Nutrition & Technology

....

for Dr. Alice Mboganie Mwangi Date...20th Sept 2010...

Dept of Food Science, Nutrition & Technology

Dedication

This work is dedicated to my dad, Mr. Samuel G. Kiharason for the moral and financial support he has continually provided for me up to this far. His unlimited love and sacrifice is an inspiration to me.

To my entire family members: mum and siblings, for their support and encouragement to me during my studies.

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I appreciate your willingness. May God bless you all.

Abbreviations and Acronyms

CIC- Conjuctival Impression Cytology

DA- Dark Adaptation

GOK- Government of Kenya

IVACG- International Vitamin A Consultative Group

KFSSG- Kenya Food Security Steering Group

MCH- Mother-child health

OFSP- Orange-Fleshed Sweet Potato

PMTCT- Prevention of Mother to Child Transmission of HIV/AIDS

ppm- Parts per Million

RAE- Retinol Active Equivalent

RDA- Recommended Dietary Allowance

RE- Retinol Equivalent

RTIs- Respiratory tract infections

U5s- Children under five years of age

UNICEF- United Nations Children's Fund

VAD- Vitamin A Deficiency

WHO- World Health Organisation

XN- Night Blindness

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Operational Definitions

Beta carotene: an orange pigment with antioxidant activity; a vitamin A precursor found in many yellow and red coloured plants

Bioavailability: the fraction of an ingested nutrient available for use in normal physiologic functions and storage

Bioconversion: a fraction of that which is converted to retinol in the body

Carotenoids: a large group of chemical compounds closely related to beta carotene in chemical structure and occurring in its association in plants

Cultivar: a type of plant that has been deliberately developed to have particular features

Dietary diversification: the art of including a variety of foods in a meal, with the aim of getting adequate nutrients through complementation

Dietary modification: the art of changing the routine diet by introducing other foods in addition to the traditional ones, increasing the amount consumed per person in a meal, or serving the usual diet/ meal with foods that will enhance absorption

High risk groups: nutritionally vulnerable groups, such as children less than five years and women of child bearing age, due to their higher levels of micronutrient requirements for rapid growth and building of new cells

Micronutrients: natural or synthetic vitamins and minerals required in the body in small amounts, that are essential for growth, development and maintenance of life and whose deficiency will cause characteristic biochemical or physical changes

Morbidity: the presence of disease or the relative frequency of the occurrence of a particular disease in a particular area

Mortality: number of deaths that occur in a given place, group and at a given time

Preformed vitamin A: the active form of vitamin A, usually retinol provided mainly by foods of animal origin

Retinitis pigmentosa: a group of inherited disorders characterized by progressive peripheral vision loss and night vision difficulties that can lead to central vision loss

Retinoids: all compounds, either natural or synthetic, similar to vitamin A (retinol) in chemical structure

Retinol: one of the active forms of vitamin A made from beta carotene in animal and human bodies; an antioxidant nutrient. Other forms are retinal and retinoic acid

Supplementation: provision of a specified dose of nutrient preparation which may be in form of tablet, capsule, oil solutions or modified food, for either treating an identified deficiency or prevention of the occurrence of such deficiency in an individual or community

Abstract

Developing countries, more so those in sub-Saharan Africa, are having to grapple with high prevalence of vitamin A deficiency. Food based approaches are being recommended as the sustainable interventions. In Kenya, orange-fleshed sweet potatoes are being recommended as one such food. This study was therefore designed to assess the potential of orange-fleshed sweet potato to improve vitamin A intake by children 25-60 months old in Rumuruti division of Laikipia district, Kenya.

Using a semi-structured questionnaire, a cross-sectional survey was carried out among 227 mothers with the target children. The situation of vitamin A deficiency was assessed using one biological and five of a composite of demographic and ecological indicators. The extent of production and consumption of sweet potato by households were also assessed. A 24-hour recall was used on a sub-sample of 32 mothers to determine dietary intake of vitamin A by the children. A focus group discussion was used to determine awareness about night blindness and its local term. As a sub-clinical indicator for vitamin A deficiency, night blindness was carried out on only 4.8% of the children; the rest had received vitamin A supplementation within the last six months. Data was coded, entered, recoded and analyzed using MS Excel, Vitamin A Intake Calculator, SPSS and Epi-Info.

None of the few children assessed showed any night blindness. However, demographic and ecological indicators indicated that the children were at risk of vitamin A deficiency: 86% households were surviving on less than one dollar per person per day and less than 75% of the children were consuming vitamin A-rich foods for more than 3 days in a week. The results indicated that 68.7% of the children had inadequate dietary intake of vitamin A in the last 24 hours. Of this group, the 25-36 months old group had consumed on average 60.8% and the 37-60 months old group, 62.7% of their RDAs.

The study established that 42% households were growing and consuming mainly white-fleshed sweet potato varieties but only 24.2% had consumed sweet potatoes in the last 7 days; only 3% had consumed for at least 3 days in the week. No child had consumed sweet potato in the last 24 hours. Potential for contribution of sweet potato to vitamin A intake by children was obtained through calculation, by assuming that an average child consumed 100g of orange-fleshed sweet potato once a day. With the consumption, the RDA for vitamin A would be met from consumption of sweet potato alone. The children within the age of 25-36 months old would be required to eat 27g of the potato, and those between 37-60 months old would require 35g of the sweet potato to meet their RDA for vitamin A.

The study concluded that sweet potatoes are a familiar and acceptable food in Rumuruti, but their contribution to vitamin A intake is minimal. Without vitamin A capsule supplementation, up to 68% of the children are at risk of VAD. However, inclusion of orange-fleshed sweet potato in their daily diets would easily meet their vitamin A RDAs and there would be no need for the vitamin A capsule administration.

1.0 INTRODUCTION

1.1 Background

The term vitamin A refers to a sub-group of chemicals that possess the biological activity of all-*trans*-retinol (Solomons, 2001). Vitamin A is a fat-soluble vitamin, pale yellow in color and consists of several chemically related substances rather than one single active compound (Guthrie, 1989). Three different forms of vitamin A are active in the body: retinol, retinal and retinoic acid. These are collectively known as retinoids and they constitute the pre-formed vitamin A. Foods derived from animals provide compounds (retinyl esters) that are easily hydrolyzed to retinol in the intestine, while those from plants provide carotenoids, some of which have vitamin A activity. These are referred to as vitamin A precursors or pro vitamin A compounds. The most important of the carotenoids is beta carotene, which can be split to form retinol in the intestine and liver. Beta carotene's absorption and conversion are less efficient than those of retinoids (Whitney and Rolfes, 1999). The richest animal sources of vitamin A are fish oils, liver and other organ meat. Full cream milk and butter, and fortified margarine are also rich in the vitamin. Palm fruits and red palm oil are the richest sources of pro vitamin A (carotenoid). Dark green leafy vegetables, carrots and deep orange root vegetables and fruits are rich in pro vitamin A, but their yield of the vitamin is variable (Solomons, 2001). When dietary intake of vitamin A in humans is below the recommended dietary allowance (RDA), vitamin A deficiency (VAD) occurs.

VAD is defined as liver stores below 20 μg (0.07 μmol) of retinol per gram (Sommer and Davidson, 2002); the situation that exists when tissue levels are depleted to a level at which health consequences occur even in the absence of xerophthalmia (Underwood and Olson, 1993). Xerophthalmia is the main clinical manifestation of VAD and is characterized by total blindness due to abnormal drying of the mucous membrane of the eye. Other clinical manifestations of VAD are anemia, growth retardation, increased infectious morbidity and mortality. There are non-clinically manifested consequences of VAD which include impaired iron mobilization, disturbed cellular differentiation and depressed immune response. VAD augments the severity, complications and risk of death associated with measles and is associated with infant morbidity, by increasing severity of disease episodes, such as diarrhea. It also increases the risk of severe illness and can be fatal with infections such as measles, diarrhea and respiratory tract infection. Prolonged low intakes of vitamin A by children 6 months to 5 years of age can lead to xerophthalmia and untimely blindness, but this is preventable. However, people are often unaware that even before blindness occurs, vitamin A deficient children face a 25% greater risk of dying from ailments such as measles, diarrhea or malaria because these are often aggravated by VAD. Children under five years of age (U5s) are at highest risk of VAD because of their rapid growth rate, which increases vitamin A requirements, the typical vitamin A deficient weaning diets and their general aversion to eating green leafy vegetables (Underwood and Olson,1993).

VAD continues to reduce child survival in Kenya by increasing both morbidity and mortality (UNICEF/GOK, 1999). From the 1999 national survey on micronutrients, mild and acute levels of VAD are together known to affect over 70% of women and children. Kenya is a country in the developing areas of the world, where majority of the population consume vitamin A mainly in the form of fruits and vegetables. It is estimated that more than 80% of dietary intakes of vitamin A in Africa and South East Asia are from pro vitamin A carotenoids. Moreover, vitamin A from plant sources is usually found in large amounts in only a few fruits and vegetables, many of which are seasonal (IFPRI, 2001). For this reason, daily per capita intake is often insufficient to meet dietary requirements. Inadequate intakes are further compromised by increased requirements for the vitamin as children grow or during periods of illness, as well as increased losses during common childhood infections (WHO, 2009).

Different strategies have been put in place to combat VAD, including promoting, protecting and supporting breastfeeding to ensure a continued source of vitamin A for infants for up to 2 years of life. Supplementation is a therapeutic or short term intervention which involves provision of mega doses of vitamin A in form of capsules to sub-populations affected by VAD. Nutrition education is also done to reinforce specific nutrition-related practices to change habits which contribute to poor health. Finally, dietary diversification and modification is a long-term strategy which plays an important role in preventing micronutrient malnutrition by increasing the availability and consumption of different varieties of micronutrient-rich foods.

1.2 Problem Statement

Kenya has been faced with a high prevalence of VAD, at 61% moderate and 14.7% severe VAD (UNICEF/GOK, 1999). The problem has been a significant public health problem and studies have confirmed it requires urgent interventions (Ngare et al., 2000). Laikipia district cannot be an exceptional in this problem. The community in the study area has seemingly poor consumption of vitamin A-rich foods in their traditional diets due to scanty production of these foods (James and Etim, 1999). Plant foods rich in vitamin A include dark green leafy vegetables, yellow to orange fruits such as mangoes, paw paws, carrots, avocado, pumpkin, passion fruit; yellow to orange root vegetables such as carrots and orange-fleshed sweet potato-all of which are either poorly produced or not produced at all in the area. Dark green leafy vegetables are occasionally included in the diets. Consumption of animal sources of the vitamin such as liver, eggs, and whole milk is also scanty because the products are unaffordable by majority of residents. There could therefore be significant levels of VAD among at-risk groups. The U5s are at higher risk of VAD because of their aversion to eat green leafy vegetables.

VAD intervention has been approached through supplementation where large doses of vitamin A are administered. This approach is, however, limited because it creates strong dependency on international funding which is not sustainable. There are also difficulties in reaching all the high-risk populations, unreliable and inconsistent delivery systems, dependence on individual compliance and a tendency to target only sub-groups of a population (low coverage).

Coverage for vitamin A supplementation for U5s in Kenya has been low; it was recorded at 33% in 2003 (UNICEF, 2006). It has been even lower in Laikipia, at 25% in 2008 (KFSSG, 2008). This is because only a few of them complete the national schedule for vitamin A supplementation, mainly due to non-compliance by mothers/caregivers who stop adherence to the schedule of maternal and child health (MCH) clinic after the child completes the measles vaccinations at the age of nine months. Moreover, the white-fleshed sweet potatoes are consumed in preference to orange-fleshed sweet potato (OFSP).

Little information exists about VAD in Laikipia district because the district has not been studied with regard to VAD. It is also not known whether the OFSP has found its way into the area, given that promotion has been ongoing in Kenya, particularly in the western parts of the country.

1.5 Justification

Supplementation is not a sustainable intervention to VAD. Like any other deficiencies, VAD requires sustainable approaches. A permanent change in food habits is a long-term and sustainable strategy to solve the problem of VAD (UNICEF/GOK, 1999). This involves producing foods rich in vitamin A, for example OFSP. When the community members consume foods rich in vitamin A, VAD will be alleviated even in a situation of low supplementation coverage, such as the 25% recorded in 2008 in Laikipia district (KFSSG, 2008). This is because there will be access to these foods for consumption by everybody. Also, since sweet potato is a familiar crop in the area, introducing OFSP would be easily accepted by the community members if it were introduced. Moreover, sweet potato is a drought-resistant crop that can withstand the climatic conditions in Laikipia: some parts being semi-arid, and given the deteriorating climatic conditions.

The project aims are inline with the Millennium Development Goals 1, 4 and 5 (Eradicate extreme poverty and hunger; Reduce child mortality; Improve maternal health) in that the ultimate situation anticipated is a community producing and consuming plenty of OFSP varieties that are excellent sources of vitamin A.

1.6 Objectives

1.6.1 Main Objective:

To determine the potential role of OFSP in enhancing dietary adequacy of vitamin A for children 25-60 months old in Rumuruti division of Laikipia district, Kenya

1.6.2 Specific Objectives:

1. To determine socio-demographic characteristics and socioeconomic status of households in the community
2. To evaluate household production of sweet potatoes and the consumption among children 25-60 months old, including OFSP
3. To determine frequency of consumption of vitamin A-rich foods by the children
4. To establish dietary intake of vitamin A by the children
5. To determine the prevalence of night blindness among the children
6. To determine the extent of helminthes infestation among the children

1.7 Hypothesis

Consumption of OFSP in Rumuruti division has potential to improve the vitamin A intake of children 25-60 months old to adequacy levels

2.0 LITERATURE REVIEW

2.1 Prevalence of VAD among children under five years

2.1.1 Global perspective

World Health Organization (WHO, 2009) indicates that VAD remains a significant public health problem at the global level. An estimated 33% (190 million) of pre-school-age children and 15% (19 million) pregnant women do not have enough vitamin A in their daily diet, and can be classified as vitamin A deficient. Furthermore, another 5.2 million pre-school-age children suffer from clinical VAD. VAD is widespread and has severe consequences for young children in the developing world.

The highest prevalence and numbers are found among countries of Sub-Saharan Africa (SSA) and South-East Asia, where more than 40% of pre-school-age children are estimated to be vitamin A deficient. Recent WHO estimates indicate that VAD is a clinical problem in 45 countries and a sub-clinical problem in 122 countries. Appendix I shows the global prevalence of VAD (WHO, 2009). Currently, about 32% of the population of SSA suffers from VAD (Kapinga et al., 2010).

2.1.2 Prevalence of VAD among children under five years in Kenya

In Kenya, both moderate and severe VAD exist and have reached public health proportions at 61% and 14.7% respectively (UNICEF/GOK, 1999). Recent research shows that deficiencies of vitamin A are of serious public health concern within the population. This is especially critical among pregnant women and young children. Both mild and acute levels of VAD in Kenya are together known to affect over 70% of these two groups. There has been a deteriorating trend of VAD, with 1994 having 40%

prevalence and 1999 having 84% (MOH/UNICEF, 2004) and studies show that VAD requires urgent interventions (Ngare et al., 2000). Table 1 shows the prevalence of VAD among various age groups in Kenya.

Table 1: Prevalence of VAD in Kenya

Group	Severe VAD%	Moderate VAD%
Children	14.7	61
<6 months	22.3	-
6-12 "	25.9	-
13-24 "	19.5	-
25-48 "	28	-
49-60 "	24.5	29.6
Mothers	9.1	-
Men	-	27

Source: Mwaniki et al, 1999.

2.2 Causes of VAD

The causes of VAD can be categorized into immediate, underlying and basic causes. A conceptual framework for these causes is shown in figure 1. Immediate causes include habitual inadequate intake of bioavailable carotenoids (provitamin A) or vitamin A to meet physiological needs (Van Jaarsveld et. al. 2005), and disease. The recommended dietary intakes are designed to prevent deficiencies for majority of the population. According to Underwood and Olson (1993), signs of VAD appear when dietary intake goes down to as low as 100 Retinol Equivalents (RE) per day. Diseases such as measles and diarrhea are immediate causes of VAD. The frequency, duration and severity of diseases/infections contribute to VAD vulnerability. Furthermore, intestinal worm infestations compete for uptake of vitamin A and also cause reduction of dietary intake by suppressing appetite. In general, infections lower the efficiency of absorption, conservation and utilization of vitamin A (Jonsson, 1997).

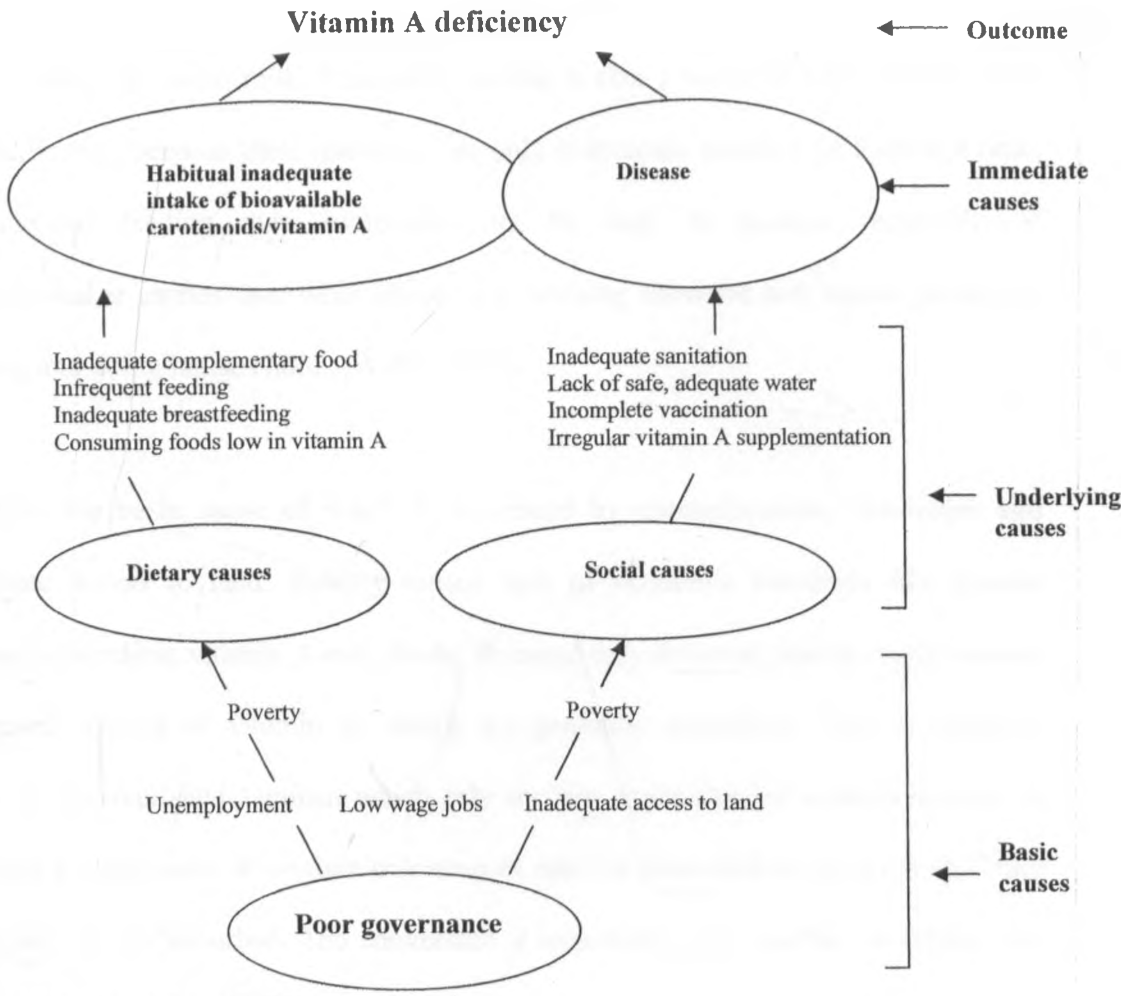

Figure 1: Conceptual framework for VAD causes

Source: Adopted from WHO, 1995

The underlying causes are both dietary and social in nature according to WHO, 1995. Social causes include inadequate sanitation, lack of safe, adequate water, incomplete vaccination and irregular vitamin A supplementation. Dietary causes include consumption of foods low in vitamin A, inadequate breastfeeding, infrequent feeding and inadequate weaning food. Inadequate breastfeeding denies the child of vitamin A in breast milk, which is in a readily absorbable form (retinol). Clinically apparent VAD is rare among populations where breast feeding prevails. From 6 months of age, complementary foods and later the family diet present a large proportion of the infant's diet. These foods may not contain vitamin A in amounts that adequately match what was being provided by breast milk. Infrequent feeding is also a cause of VAD. Infants need frequent feeding because their stomachs can only hold small amounts of food at a time. The frequent feeding may sometimes not be easy to practice, especially if mother/caretaker carries over other chores e.g. fetching firewood and water, gardening, shopping and doing house chores (WHO, 1995).

Poverty is the basic cause of VAD. It is created by unemployment, low-wages and inadequate access to land. Poverty means lack of economic resources like income required to purchase vitamin A-rich foods. Because only foods of animal origin contain pre-formed sources of vitamin A, which are generally expensive, VAD is confined largely to impoverished families which rely on less expensive pro-vitamin sources to meet their requirements. Pro-vitamin A sources must be converted to retinol in the body before they can be absorbed. The conversion is sometimes poor and the absorption low when meals do not contain lipids (WHO, 1995).

Poor governance has been named as a basic cause of VAD (Kent, 1994). Kent argues that a government's basic job is to provide a system where people can meet their own and their children's basic needs; and that the states are obliged, regardless of the level of economic development, to ensure respect for minimum subsistence for all. Kent adds that chronic malnutrition, which includes VAD, reflects government's failure in its responsibility. It has been suggested that nutrition is a national issue and that politicians should have a commitment for alleviating all forms of malnutrition, including vitamin A.

2.3 Clinical signs of VAD

Deficiency signs and symptoms of vitamin A show after liver stores are depleted to very low levels, which could be caused by any of the causes of VAD discussed earlier. VAD manifests itself in the following ways:

Night blindness

This is inability to see in dim light of evening (dusk). It is caused by lack of vitamin A at the retina i.e. back of the eye. In night blindness, the blood bathing the cells of the retina does not supply sufficient retinal to rapidly generate visual pigments bleached by light. The person loses the ability to recover promptly from the temporary blinding that follows a flash of bright light at night or simply is unable to see after the light goes out (Whitney and Rolfes, 1999). Night blindness is the mildest sign of VAD, cured in one or two days upon vitamin A supplementation (MOH/UNICEF, 2004).

Bitot's spots

These are foamy, soapy whitish patches on the white part of the eye. They are readily recognized and serve as a useful clinical criterion for assessing the vitamin A status of the population. The affected individuals are usually of school age or older and may have a history of previous bouts of night blindness or xerophthalmia. Bitot's spots are an easily recognized and relatively specific marker of active VAD, at least among preschool children, and are more prevalent than corneal disease (WHO, 1996). They may not disappear completely after treatment, especially in older children and adults, but they do not affect the eye sight.

Conjuctival xerosis

The conjuctiva looks dry and slightly rough or wrinkled, instead of wet, smooth and shiny. It is cured within one or two weeks upon vitamin A supplementation.

Corneal xerosis

The surface of the cornea is cloudy and dry. Early corneal xerosis may be cured in one or two weeks upon supplementation. More serious lesions are incurable.

Corneal ulcers

When corneal xerosis is not cured early enough, ulcers (holes) may form on the surface of cornea. Vitamin A can cure the ulcerations, but usually scar remains, which may affect the eyesight.

Xerophthalmia

This is a condition whereby the mucous membranes of the eye become abnormally dry due to VAD, leading to total blindness. It is caused by lack of vitamin A at the front of the eye, the cornea. Xerophthalmia develops in stages: first, the cornea becomes dry and hard, a condition known as xerosis. Corneal xerosis can quickly progress to keratomalacia, the softening of the cornea that leads to irreversible blindness (Whitney and Rolfes, 1999).

Keratomalacia

This is ulceration, distortion and softening of the cornea with eventual perforation and iris prolapse and infection (MOH/UNICEF, 2004).

2.4 Nature and occurrence of vitamin A in foods

Vitamin A is a generic term reserved to designate any compound possessing the biological activity of retinol (Blomhoff, 1994). Retinol is the preformed vitamin A which is the biologically active form, only found in foods of animal origin (WHO, 1994). The main dietary sources of vitamin A are pro vitamin A carotenoids from vegetables, and preformed retinyl esters from animal tissues. Vitamin A and its derivatives belong to a much larger class of structurally related compounds, termed the retinoids (Olson, 1991). Retinoids, which are derivatives of vitamin A, include a wide variety of synthetic and natural compounds, including vitamin A precursors, the carotenoids; also called provitamins (Guthrie, 1989). The carotenoids are a group of very closely related compounds which are responsible for the yellow-red colors of plants and animal products. Of over 500 carotenoids that have been isolated from nature, only about 50 possess biological activity. Thus the term pro vitamin is used as a generic indicator for all carotenoids that show the biological activity of vitamin A.

The most active and quantitatively the most important of these pro vitamins is all-*trans* ß-carotene and is the major pro vitamin carotenoid (Olson, 1991). It yields two molecules of vitamin A on hydrolysis, while the others (e.g. alpha and gamma carotene) yield one molecule of vitamin A and another molecule of a related but metabolically inactive molecule that has no vitamin A activity. The vitamin A activity of ß-carotene is, therefore, greater than that of the other carotenoids (Hagenimana et al, 1998).

The terms *cis* and *trans* have traditionally been used to denote various isomers of vitamin A. however, the current chemical notation is *Z* for *cis* and *E* for *trans*. The *trans* notation refers to the isomers with more absorption and absorbance ability than the *cis* isomers. All-*trans*-retinol, an alcohol, is the parent retinoid compound (Olson, 1991).

2.5 Absorption and metabolism of vitamin A

After foods are ingested, preformed vitamin A and pro vitamin A carotenoids are released from proteins by action of pepsin and proteolytic enzymes. In the stomach, the free carotenoids and retinyl esters congregate in fatty globules which enter duodenum, where they are broken up for ease of digestion. The resultant micelles containing retinol, carotenoids, sterols, some phospholipids and fatty acids then diffuse into microvillus and make contact with the cell membranes, where they are absorbed into mucosal cell. The bioavailability and digestion of vitamin A and carotenoids are affected by overall nutritional status of individual and integrity of intestinal mucosa, as well nutritional factors (protein, fat, vitamin E, zinc and iron). Some fibers e.g. highly methoxylated pectins, markedly reduce carotenoid absorption. Bile salts are an absolute requirement for carotenoid absorption. The overall absorption of dietary vitamin A is approximately 80-90%, with somewhat less efficient absorption at very high doses. On the other hand, the efficiency of absorption of carotenoids from foods is 50-60%, depending on its bioavailability. The absorption efficiency of carotenoids reduces markedly at high intakes/doses (Olson, 1991).

The vitamin A-containing chylomicrons are removed from circulation by the liver after being slightly changed by lipoprotein lipase. Vitamin A is deposited in the liver in lipid droplets for storage. When needed, vitamin A is released as retinol, which is then attached to a transport protein called retinol-binding protein (RBP). As this complex enters the blood plasma, it is attached to another protein, pre-albumin (also called transthyretin). In this form, retinol is transported to the tissues where it can be used for essential functions (Guthrie, 1989). In this way, the liver provides tissues with optimal amounts of retinol in spite of huge fluctuations in daily vitamin A intake (Blomhoff, 1994). Both RBP and transthyretin make retinol more soluble to facilitate its transport in the blood and also make it part of a larger molecule to protect it from being filtered out and lost through kidneys. Once delivered to the cell, vitamin A is picked up by specific proteins within the cell known as CRBP (cellular retinol-binding protein) and CRABP (cellular retinoic acid-binding protein), which specifically bind retinol and retinoic acid. Enzymes are needed at many stages, and transport proteins are needed to deliver vitamin A to the cells and to mobilize vitamin A reserves from the liver. The depressed utilization of vitamin A in protein deficiency can be explained by the need for proteins in vitamin A metabolism (Guthrie, 1989).

2.6 Functions of vitamin A in the human body

The active forms of vitamin A participate in three essential functions: visual perception, cellular differentiation and the immune response (Solomons, 2001).

Vision

Vitamin A plays two indispensable roles in the eye: it helps maintain a crystal-clear outer window, the cornea, and it participates in the conversion of light energy into nerve impulses at the retina. Light passes through the cornea and strikes retina cells which contain pigment molecules called rhodopsin that absorb light. Each rhodopsin has a protein called opsin bonded to a molecule of retinal. When light energy enters the eye, rhodopsin responds by changing shape and becoming bleached. Simultaneously, the retinal shifts configuration from cis to trans, in which form it cannot remain bonded to opsin. It is therefore released, making the opsin to change shape-this disturbs the cell membrane and generates an electrical impulse that travels along the cell's length. At the other end, the impulse is transmitted to a nerve cell, which conveys the message to the brain. Much of the retinal is then converted back to its active cis form and combined with the opsin protein to regenerate the pigment rhodopsin, though some retinal may be oxidized to retinoic acid, a biochemical dead end for the visual process (Whitney and Rolfes, 1999).

When a person is walking in a brightly lit street, the light causes excessive bleaching of rhodopsin and, on entering a dimly lit room, vision will be possible only when a sufficient amount of rhodopsin has been reformed. The inability to adapt to the dim light, known as night blindness, is due to a failure of a process known as dark adaptation. The speed with which the eye adapts after exposure to bright light is directly related to the amount of vitamin A available to reform rhodopsin. In spite of the importance of vitamin A in visual process, only 0.01% of the vitamin is found in the eye. Vitamin A supplementation does not improve normal vision but does improve poor vision caused by VAD (Guthrie, 1989).

Reproduction and growth

In men, retinol participates in sperm development, and in women, vitamin A supports normal fetal development during pregnancy. Growth failure is common in children with VAD, and when given vitamin A supplements, they gain weight and grow taller. The growth of bones shows that growth is a complex phenomenon of remodeling. To convert a small bone into a large one, the bone-remodeling cells must 'undo' some bone parts, and vitamin A is involved in the 'undoing' (Whitney and Rolfes, 1999). Growth failure will occur before most other symptoms of VAD except night blindness (Guthrie, 1989).

Immunity

According to Guthrie (1989), retinoic acid is important for immune system functions. Epithelial cells are found not only on the outer protective layer of the skin, but also in the genitourinary and respiratory tracts. Formation of these cells depends on vitamin A, and the vitamin is needed continuously to maintain the health of the cells because they are always being lost and replaced. When vitamin A is absent, dry and hardened (keratinized) cells develop, which are unable to form and secrete mucus; they also lack cilia-hair-like projections that prevent accumulation of foreign material on the cell surface by constantly moving back and forth, protecting the body against infection. When the body is deficient in vitamin A, many abnormal epithelial tissues may occur in the following areas:

Eye: cornea dries and hardens, leading to xerophthalmia and blindness.

Respiratory tract: ciliated epithelium of nasal passage dries and cilia are lost. Infection barrier is removed. Salivary glands dry up and mouth becomes dry and cracked.

Gastro-intestinal tract: mucosal membrane secretions decrease. Tissues become dry and slough off, affecting digestion and absorption.

Genitourinary tract: as epithelial tissue breaks down, problems like urinary tract infections and vaginal tract infections increase.

Skin: as skin becomes hard and scaly, small pistules or hardened pigmented eruptions appear around hair follicles: follicular hyperkeratosis (Guthrie, 1989).

Reproduction

The retinoids, e.g. retinoic acid are necessary to support normal sexual maturation during adolescence and function of the adult reproductive system. A deficiency causes glandular degeneration and sterility.

Antioxidant capacity

Beta carotene has been shown to have antioxidant capacity, raising interest in its ability to protect persons as they grow older from cell damage caused by free radicals. The free radicals damage DNA cell membranes and cell compounds, or may even kill the cell. These cumulative effects advance the ageing process (through cell deterioration) antioxidant substances scavenge free radicals in the cells (McLaren, 2004).

2.7 Recommended dietary allowances for vitamin A

According to FNB (2001), the RDA gives the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in each age and gender group. An adequate intake (AI) is set when there are insufficient scientific data to establish an RDA, and it may meet or exceed the amount needed. Information is insufficient to establish RDA for vitamin A for infants and AIs have been established based on the amount of vitamin A consumed by healthy infants fed breast milk. There is no RDA for beta-carotene and other carotenoids. The Food and Nutrition Board states that consuming 3mg to 6mg of beta-carotene daily (equivalent to 833 IU to 1667 IU of vitamin A) will maintain blood levels of beta-carotene in the range associated with a lower risk of chronic diseases. Table 2 shows the RDAs for all ages in the human lifecycle.

Table 2: RDAs for vitamin A

Population group	1988 FAO/WHO (RE[a]/day)[b]	2000 U.S Dietary Reference Intake (RAE[c]/day)[d]	
		Males	Females
0-6 months		400 (AI)[e]	
7-12 months		500 (AI)[e]	
0-1 yrs	350		
1-3 yrs		300	300
1-6 yrs	400		
4-8 yrs		400	400
6-10 yrs	400		
9-13 yrs		600	600
10-12 yrs	500		
12-15 yrs	600		
14-18 yrs		900	700
Pregnancy	600		750 (≤18 yrs) 770 (19-50 yrs)
Lactation	850		1200 (≤18 yrs) 1300 (19-50 yrs)

Source: Solomons, 2001.

[a]Retinol Equivalents: a conversion unit of retinol, ß-carotene and other pro vitamin carotenoids of 1:6:12, developed by FAO/WHO expert committee in 1967.
[b]Source: FAO/WHO recommendations(1988).
[c]Retinol Active Equivalents: the new conversion unit with a relative proportion of retinol, ß-carotene and other pro vitamin A carotenoids of 1:12:24 (Solomons, 2001).
[d]After the Dietary Reference Intakes process, converted to expressions of Recommended Dietary Allowances (FNB, 2001).
[e]Adequate Intake

2.8 Vitamin A toxicity

Among the essential nutrients, pre-formed vitamin A has one of the greatest potentials for producing toxic consequences when consumed in excess (Solomons, 2001).The condition caused by vitamin A toxicity is called hypervitaminosis. It is caused by over consumption of preformed vitamin A, not carotenoids (Higdon, 2003). Regular, high intakes of ß-carotene can lead to accumulation of the carotenoid in the skin, a condition called carotenodermia (Combs, 1998). Pro vitamin A carotenoids are generally considered safe because they are not associated with specific adverse health effects. Their conversion to vitamin A decreases when body store are full, and a high intake can turn the skin yellow, but this is not considered dangerous to health (FNB, 2001). The fat-soluble nature and long biological half-life of vitamin A favor certain toxic features. When massive amounts of preformed vitamin A are taken acutely or large amounts are consumed cumulatively, manifestations of systemic toxicity ensue. Acute hypervitaminosis manifests itself in abdominal pain, nausea, vomiting, headache, fatigue, irritability and generalized desquamation of skin. Manifestations of chronic hypervitaminosis include mucocutaneous (dry skin, follicular hyperkeratosis, dermal desquamation, dry mouth, brittle hair), ocular (dry eye, ocular pain, papilledema), gastrointestinal (anorexia, cirrhosis, acsites), neuromuscular and psychological (headache, myalgias), rheumatological (arthritis, bone pain), and endocrine (polyuria, polydipsia, hypercalcemia, hypercalciuria) lesions (Solomons, 2001).

The Food and Nutrition Board (2001) has established the Tolerable Upper Intake Levels (ULs) for vitamin A that apply to healthy populations. This is the maximum daily intake unlikely to result in adverse health affects. The UL (600 RAE for children 1-3 years, and 900 RAE for children 4-5 years old) was established to help prevent the risk of vitamin A toxicity, and does not apply to malnourished individuals receiving vitamin A as a means of preventing VAD, or those being treated with vitamin A for diseases such as retinitis pigmentosa.

2.9 Assessment of VAD

VAD is measured using direct indicators (clinical and sub-clinical), and indirect indicators that are ecological and demographic in nature (WHO, 1996), some of which are discussed hereafter. Tables 3 and 4 show the prevalence of different indicators of VAD, at levels indicating a public health problem.

Table 3: Indicators of clinical VAD-xeropthalmia- in children 6-71 months old

(Prevalence of any one or more indicators signifies a public health problem)

Indicator	Minimum prevalence
Conjunctival xerosis / with Bitot's spots (X1B)	>0.5%
Corneal xerosis (X2)/ ulceration (X3A)/ keratomalacia (X3B)	>0.01%
Corneal scars (XS)	>0.05%

Source: WHO, 1996

Table 4: Biological indicators of sub-Clinical VAD in children 6-71 months old

(Prevalence below cut-offs to define a public health problem and its level of importance)

Indicator (cut-off)	Mild	Moderate	Severe
Functional			
Night blindness (XN)-present at 24-71 months	>0-<1%	≥1-<5%	≥5%
Biochemical			
Serum retinol (≤0.7μmol/l)	>2-<10%	>10-<20%	≥20%
Breast milk retinol (≤1.05μmol/l) or 8 mg/g milk fat	<10%	≥10-<25%	≥25%
RDR (≥20%)	<20%	≥20-<30%	≥30%
MRDR (ratio≥0.06)	<20%	≥20-<30%	≥30%
+S30DR (≥20%)	<20%	≥20-<30%	≥30%
Histological			
Conjunctival Impression Cytology (CIC)/Impression Cytology with Transfer (ICT)-abnormal at 24-71 months	<20%	≥20-<40%	≥40%

Source: WHO, 1996

2.9.1 Serum retinol

Serum retinol levels reflect the vitamin A status only when vitamin A stores are severely depleted (<0.07 μmol/g liver) or excessively high (>1.05 μmol/g liver). When liver limits are between these limits, serum retinol concentrations are homeostatically controlled and levels remain relatively constant and do not reflect total body reserves of vitamin A (Gibson, 2005).

Blood for analysis is collected from individuals by either a venepuncture or finger prick, protected from light and chilled immediately. Later the blood is clotted, after which it is centrifuged and serum separated by centrifugation within 12 hours of drawing. Serum is then stored and protected from light, oxygen and desiccation and frozen until analyzed. The specificity of serum values can be confounded because RBP is an acute phase protein. It can be profoundly affected by febrile infections, even in individuals with relatively normal stores of vitamin A. Thus, acute and underlying chronic infections can confuse specificity in interpreting serum values when cut-off points are used. Furthermore, RBP has a short half-life that may limit synthesis in the presence of PEM, and hence hinder the mobilization of retinol form stores. In addition, serum retinol values change with age, increasing from lower levels at birth to adult levels after puberty (WHO, 1996).

2.9.2 Breast milk concentrations

Breast milk retinol concentrations can indicate when the maternal vitamin A status is suboptimal, as lactating women then secrete breast milk with a reduced content of retinol. This can be used as an indirect indicator of the vitamin A status of breastfed infants (Gibson, 2005). Milk samples should be collected from mothers 1-8 months postpartum when breast milk proximate composition is likely to provide the major source of vitamin A for the infant, with complementary foods contributing little if any. It will also avoid colostrum and transitional milk which are very high in vitamin A

Samples (5 ml) are obtained by manual expression or using a breast pump into light-proof tubes/vials with air-tight caps. The samples can be stored at -20^0c until analyzed. For assessment, the sensitivity and specificity of breast milk concentration for identifying VAD in individual infants are not high. Nonetheless, the association between vitamin A in breast milk and other maternal and infant vitamin A status indicators is sufficiently strong that it is a useful indicator at the population level. In vitamin A sufficient populations, average breast milk concentrations range from 1.75-2.45 μmol/L, whereas in vitamin A deficient population, average values are below 1.4 μgmol/L. A cut-off of ≤1.05 μmol/L (or ≤8μg/g milk fat) is selected based on considerations of the dietary vitamin A requirement of infants and its usefulness in monitoring changes in the vitamin A status of mothers. For an infant who is exclusively or almost exclusively breast-fed (breast-fed for 0-6 months and partially breast-fed from 6-12 months), a milk concentration of at least 1.05μmol/ provides enough vitamin A to meet metabolic needs but allows for little or no liver storage of vitamin A. This cut-off thus, represents the minimum concentration required to prevent sub clinical deficiency in the first 6 months of life (WHO, 1996). Table 5 shows the prevalence of breast milk values in a population of lactating mothers that identifies a VAD public health problem.

Table 5: Prevalence of breast milk Values ≤1.05μmol/L in a population of lactating mothers and minimum sample sizes for identifying a VAD public health problem

Level of importance as a public health problem	Prevalence	Minimum sample size [1] 20%	50%
Moderate	≥10-<25%	865	139
Severe	≥25%	289	47

[1] Minimum sample size requirement for anticipated prevalence with relative precision of 20% and 50% at the 95% confidence level
Source: WHO, 1996.

2.9.3 Xerophthalmia

This includes identifying presence or absence of functional signs of insufficient vitamin A as well as changes in the eye (Guthrie, 1989). Xerophthalmia refers to clinically obvious eye signs, which are well established indicators of severe VAD i.e. Bitots spots, corneal xerosis, keratomalacia and corneal scars. They are however, rare in most surveys and a large sample size is required to establish their prevalence (WHO 1996).

2.9.4 Night blindness

XN, or the inability to see after dusk or at night, is frequently reported among young children and women of reproductive age in developing countries with moderate to severe VAD. It is the most common ocular manifestation of VAD and is often described by specific terms in cultures where the prevalence is high. Poor dark adaptation resulting in XN arises when there is reduced production in the rods of the visual pigment rhodopsin, or opsin protein bound to the retinal form of vitamin A (Gibson, 2005). XN in children 24-71 months of age can be assessed only by taking history from mothers, through an interview technique. For children below 24 months of age, this may not be a reliable indicator, since very young children are not particularly mobile after dark, hence their XN may go unnoticed. The children may also continue breastfeeding up to 24 months, thus XN may not occur until after weaning (WHO, 1996). Night blindness and dark adaptometry have been proposed as population assessment methods. Dark adaptometry is a good marker of early physiological impairment in VAD disorders (Ramakrishan and Danton-Hill, 2002). Determining sample size for assessing night blindness in children between 2-5 years at specified anticipated prevalence in the community has been provided (Sommer and Davidson, 2002) and is shown in table 6.

Table 6: Criterion to determine sample size requirements for VAD exceeding relevant prevalence

Criterion for Deficiency	Actual prevalence anticipated in the population (%)	Sample size required for probability of detection: 80%	Sample size required for probability of detection: 90%
XN among children 2-5 y: 1.0%	1.50	418	968
	1.75	216	495
XIB among children 2-5 y: 0.50%	1.00	280	649
	1.50	105	242
Serum retinol <0.70 µmol/L among children 2-5 y: 15.0%	17	249	578
	20	46	105
XN (by history) during last pregnancy: 5.0%	6.5	191	443
	8.0	58	134

Source: Sommer and Davidson , 2002.

2.9.5 Rapid dark adaptation test

Before XN develops, disturbances in dark adaptation occur. These can be detected by a specifically designed non-invasive test, suitable for field condition. This test requires a light source, a dark, non-reflective work surface, a standard x-ray view box and sets of red, blue and white discs Measurements are done in the first few minutes of dark adaptation. This test is, however, not sensitive to the early signs of VAD Since the measurements rely on cones (light vision cells) in the retina instead of the rods (dark vision cells). The test is also not appropriate for pre-school children who are too young to perform the test accurately; unfortunately this is the group most at risk of VAD (Gibson, 2005).

2.9.6 Impression cytology

VAD generally means that the integrity of epithelial cells is compromised. In VAD, the epithelial cells are flattened and enlarged, and there is a marked reduction or absence of goblet cells (mucin-secreting cells). Specimens are taken either by hand (by applying a strip of filter paper to the temporal portion of the bulbar conjunctiva), or by a disk applicator. The former is more acceptable in the field, while the latter has caused concern among subjects and mothers, though it is quicker, and more reliable. The disk may be more widely accepted in clinics while the hand-held strip is more exportable into homes and appears less invasive.

After obtaining the samples, the specimens are then subjected to either of two procedures: impression cytology with transfer (ICT) or conjunctival impression cytology (CIC). For ICT, the sample of cells adhering to the filter-paper is immediately transferred to a clear microscope slide and immersed for 20 minutes in a single staining solution with ethanol as a fixative. The slide is rinsed, allowed to dry and stored without processing until evaluated. Staining is easy in the field as it requires one staining solution and no special storage requirements. However, cleanliness and good practice are crucial to obtain a good transfer from the filter paper to the slide. ICT samples are minimally affected by exposure to atmospheric moisture during storage and can be retained indefinitely without mounting.

For CIC, cells retained on filter paper are stored in a small bottle in a fixative of acetic acid, water and formaldehyde, which can be maintained t room temperature for months. Staining process takes several steps; requiring more reagents and is best accomplished at a base laboratory; hence this method is more expensive compared with ICT, although it is objective, reliable and more appropriate for assessing VAD. Its main advantage is its ability to demonstrate the condition in the early stages. It is also simple and specific One should avoid moisture during mounting and storage because this will render the strip opaque and unreadable. This may be difficult in some environments (WHO, 1996).

2.9.7 Ecological and related indicators

According to WHO (1996), supportive evidence of VAD is gained from information on nutritional status, dietary, disease patterns and social economic status. These indirect indicators help to identify areas or populations where VAD is likely to be prevalent by focusing on factors responsible for, or contribute to, the problem's occurrence. These indicators however, do not replace biological indicators and can not be used alone for determining the vitamin A status of populations, or to define whether a population has VAD problem of public health significance. However, a composite based on them can be use to corroborate biological criteria to determine if there is a public health problem.

2.9.7.1 Nutritional status and diet-related indicators

These include breastfeeding patterns, anthropometric indicators of protein energy malnutrition, prevalence of low birth weight and food consumption patterns. A pattern of breast feeding up to 18 months, inclusive of vitamin A containing complementary foods from 6 months onwards, is protective against clinical VAD. However, vitamin A-rich complementary foods, or vitamin A supplements are needed from about 6 months of age to maintain adequate body stores particularly when mothers are also malnourished. It is suggested that a community is at high risk of VAD when 50% or more of the children stop breastfeeding at the age of 6 months or less, or 75% or more of children 6-17 months old do not receive vitamin A containing complementary foods at least 3 times per week.

Food consumption patterns in a community are assessed by food frequency method to give information on how often certain foods are consumed. The primary purpose of the method is to estimate whether vitamin A containing foods are consumed regularly enough to meet body requirements. The result of a survey can be used to rank the risk of VAD i.e. a population is at risk of VAD when 75% or more of the U5s consume vitamin A rich foods <3 times a week.

Nutritional status of children is measured using anthropometric measurement, and is used to reflect NS of the rest of the population. Stunting (<-2z scores of height for age) is an indicator of chronic dietary deprivation, while wasting (<-2z scores of weight for height) is a measurement of recent inadequate food intake. These two are associated with high risk of VAD. It is hence suggested that a population is at risk of VAD when >30% of children under five years are stunted and /or 10% are wasted. A high prevalence of LBW (<2.5 kg) reflects maternal under nutrition. It also suggests the likelihood of absence of vitamin A stores in newborns and hence a high risk of VAD. It is suggested that a prevalence of ≥15% LBW indicates a VAD high risk area/population (WHO, 1996).

2.9.7.2 Health-related indicators of VAD

These include immunization, measles case fatality (MCF) and disease prevalence rates. Immunization coverage rates are indirect indicators of health system management. It can be interpreted that risk of VAD is increased when coverage rates for full immunization of especially measles fall below 50%. There is well established association between the severity of measles and VAD. MCF is a possible indicator and it has been suggested that VAD problem exists in a community when MCF rate is >1%.

Diseases such as diarrhea, acute lower respiratory infection and helminthic infections are associated with depressed appetite, depressed absorption efficiency and /or increased metabolic utilization and urinary loss of vitamin A. Their prevalence is used to identify VAD high risk area/population. It is suggested that an area or population has a high risk of VAD when a 2 week prevalence rate of diarrhea is >20%, fever is >20% and helminthic infection is >50% among pre-school age children.

2.9.7.3 Socio-economic indicators of VAD

These are useful pointers of a population's vulnerability to VAD. The indicators are most useful as supporting evidence of other more specific indicators. They include maternal education and literacy, income/employment levels, access to safe drinking water, access to health and social services, access to land, agricultural services and inputs. It is suggested that a population is at high risk when >50% of women 15-45 years of age are illiterate, >50% of households spend >70% of their income on food, <50% of households have adequate water supply, and populations living in poverty are >10km from health facilities (WHO, 1996).

2.10 Interventions in VAD

Different strategies have been put in place to combat VAD. These strategies include promoting, protecting and supporting breast feeding; supplementation with pure vitamin A capsules; dietary diversification and modification; and nutrition education.

2.10.1 Promoting, protecting and supporting breast feeding

This strategy aims at ensuring a continued source of vitamin A for infants. Breastfeeding provides a complete source of nutrition for the first six months of life, half of all requirements in the second six months of life, and one third of requirements in the second year of life. Breast milk also boosts a baby's immunity that protects against childhood illnesses associated with VAD. Breastfeeding should therefore be promoted, protected and supported through: baby-friendly hospital initiative; improvement of maternal and child health; postpartum supplementation of vitamin A; and establishment of breastfeeding support groups at community level.

2.10.2 Supplementation

This is a therapeutic or short term intervention that involves provision of high doses of vitamin A in form of capsules to sub-populations affected by VAD. In Kenya, there are policy guidelines on vitamin A supplementation which are currently in force, targeting postpartum mothers and young children. Table 7 shows the National schedule for routine Vitamin A Supplementation. This has been the main strategy for combating VAD since the early 1990's. The National Development Plan (1994-96) called for the expansion of massive dose capsules to include children "at-risk" and lactating mothers (GOK, 1991). Such programs are already quite costly, dependent on capsule donations from UNICEF and are have poor coverage.

Table 7: Schedule for routine vitamin A supplementation in Kenya

Target Group	Dosage (IU)	Frequency	Timing/ schedule
Lactating mothers (not pregnant)	200,000	Single dose	At delivery or during BCG vaccination (within 4 weeks of delivery)
Infants 6-11 months	100,000	Single dose	During MCH contacts
Children 12-59 months	200,000	Single dose every 6 months	During MCH contacts and any other community contacts

Source: Micronutrient Initiative/ UNICEF (2008)

2.10.3 Nutrition education

Nutrition education is done to reinforce specific nutrition-related practices/behavior to change habits which contribute to poor health. Nutrition education programs must have the components of: increasing nutrient knowledge and awareness of the public and policy makers on vitamin A, promoting desired food behavior and nutritional practices, and increasing diversity and quantity of family food supplies (MOH/UNICEF, 2004)

2.10.4 Dietary diversification and modification

This is a long term strategy which plays an important role in preventing micronutrient malnutrition by increasing the availability and consumption of different varieties of micronutrient-rich foods. Dietary diversity will be achieved through: high production and consumption of vitamin A-rich foods, plant selection and breeding to increase beta-carotene levels, maintaining beta carotene levels in commonly eaten foods through improved food storage and preservation and better food preparation methods (MOH/UNICEF, 2004).

2.11 Sweet potato as source of vitamin A

2.11.1 The sweet potato

The sweet potato originated from the tropical Americas and spread to most of the world's tropical, sub-tropical and warmer temperate regions (Woolfe, 1992). It has been established as one of the important food security crops in Kenya when maize is in short supply or during drought (Mutuura et al., 1992). This is because of its ability to adapt to a wide range of climatic conditions, including those found in marginal areas where there is chronic crop failure. Also, its ability to establish ground cover fast enables it to suppress weeds, control soil erosion and maintain soil fertility; making it an attractive crop for Kenya's farming systems. Further more, it does not require high levels of input since the rapid growth of vines to form ground cover eliminates the need for cultivation or use of herbicides. The crop can be planted over a broad range of time without considerable yield loss.

Insect damage is non-yield reducing and fungal diseases are not a problem in the growing crop; hence insecticides and fungicides are unnecessary. Ability to grow in relatively dry conditions makes it require no irrigation (it is a drought- resistant crop). It is also a fast-maturing crop: takes 3-5 months to get ready. Early maturity is important for food security and enabling people to get income early to meet cash obligations e.g. school fees. Besides, the sweet potato has a cornucopia of uses; these range from direct consumption of fresh roots/ leaves to processing into animal feeds, starch, flour, candy and alcohol (CIP, 1996).

In spite of the benefits associated with sweet-potato, its production and utilization has, however, been rather low in most parts of the world. This is due to the low status accorded to both roots and vines because of their image as a substitute crop, a "poor man's" food or an insurance crop. This is because of the fact that it is typically grown and consumed by resource-poor households, and is able to give satisfactory yields under adverse climatic and soil conditions as well as under low or non-use of external inputs (Carey et al., 1999). In most parts of Kenya, people do not perceive it as part of the main family diet: in central Kenya, it plays only a minor role as an alternative breakfast food or snack. In western Kenya, however, it is a supplementary staple and many people consume it boiled whole or mashed with legumes.

There are many different varieties of sweet potato cultivars e.g. white-fleshed dry-tasting cultivars (over 30% dry matter) and orange-fleshed soft-tasting cultivars (about 20-25% dry matter). Other cultivars have yellow, cream or even purple flesh color, and each of these varieties have different contents of beta-carotene.

2.11.2 Production and consumption of orange-fleshed sweet potato in Kenya

Under the umbrella of VITAA (vitamin A for Africa), 40 partner agencies from the health, nutrition and agricultural sectors have agreed to work together to extend the impact of OFSP in seven partner countries in Africa; Ethiopia, Mozambique, Ghana, Kenya, South Africa, Tanzania and Uganda. The goal of this initiative is to alleviate VAD among young children and pregnant and lactating mothers.

International Potato Centre (CIP) and its partner organizations have taken up the food-based option to combat VAD in Sub-Saharan Africa through promotion of OFSP variety which has the highest beta carotene content (Takahata et al., 1993). The yellow and white fleshed varieties which are, ironically, the most widely consumed, have very low carotenoid content (Hagenimana et al., 1998).

In Kenya, the OFSP was first introduced in Western Kenya, particularly Kakamega, since Western Kenya has been a good producer of sweet-potato, basically the white fleshed variety. The OFSP has shown stable yield performance in a wide range of environments, as well as becoming more popular among children, the most vulnerable group. The OFSP-based weaning recipes have been received well and are liked by children. CIP intends to work with the health and nutrition sector to maximize the potential for the OFSP in boosting access to vitamin A. Although several other foods can be a source of beta carotene, the OFSP seems to be the best candidate crop (GOK, 1991). It is a fast maturing crop (3-5 months), as compared to other crops e.g yams mature at 6-12 months (Benjamin et al., 2007). Besides, the yields for sweet potato are much higher than that of other related crops (FAO, 1997) and the provitamin A in it appears to be more bioavailable than that from other sources of vitamin A e.g. dark-green leafy vegetables (De Pee et al., 1998).

2.11.3 Nutritional value of sweet potato

Sweet potato is one of the highest yielding crops in terms of production per unit area, exceeding that of major cereals (Table 8), and with higher food value (Woolfe, 1992).

Average energy and protein production by sweet potatoes per hectare are of the same order as, or higher than for cereals, legumes, and other root crops (Table 8).

Carbohydrates

Carbohydrates make 80-90% of dry matter in sweet potato. The sweet potato carbohydrates consist mainly of starch, sugars and some amounts of pectin, hemicelluloses and celluloses. Carbohydrate content influences texture including firmness, dryness, mouth feel and taste. The main nutritional role of sweet potato carbohydrates is to provide a cheap source of energy. It compares favorably as energy source with boiled beans, boiled rice and cereal porridges and noodles (Woolfe, 1992).

Table 8: Energy and protein production of sweet potato compared to other crops

Crop (Fresh matter)	Yield/ha. (ton) Av 1998-1996	Energy K/J/100g	Crude fat g/100g	Energy MJ/ha.	Crude protein kg/ha.
Sweet potato	9.8	500	1.5	49,000	147
Potato	4.3	335	1.8	14,400	77
Cassava	1.77	630	1.0	5,000	81
Maize	1.2	1,570	10.0	27,800	177

Source: FAO, 1997.

Proteins

The protein content of sweet potato is relatively low: about 5%, but varies widely between 1.3% and 10% (Collins and Walter, 1982). On the ability to meet daily requirements for protein, it has been reported that sweet potato alone is not able to satisfy the requirements of growing children but can maintain adults at a marginal level of protein adequacy (Huang, et al., 1979).

Vitamins and minerals

The most abundant vitamins found in sweet potatoes are vitamins A and C. Others include vitamins B1, B2, B5, B6, niacin, folic acid and vitamin E. Among all the sweet potato varieties, the OFSP is the best source of beta-carotene, as shown in Table 9. Besides, the beta-carotene in the OFSP is more bioavailable compared to other plant sources. OFSPs also contain medium amounts of iron (up to 40 ppm of dry matter) and zinc (up to 15 ppm of dry matter).

The RDA of vitamin A for children is easily supplied by only about 100g of OFSP. Studies have shown that small quantity of OFSP (70-100g) is required for daily requirements of pro-vitamin A for adults as compared to 9000g required for white-fleshed variety (Low et al., 1997). Some OFSP varieties tested by CIP have yielded as high as 8000mg of beta-carotene per 100g fresh weight.

Table 9: Amounts of fresh storage roots (g) of sweet potato required for supplying the RDAs of vitamin A to different age groups

Age group (Yrs)	RDA (RE)	Amount (g) of storage root to supply the required pro vitamin A content			
		White	Pale-yellow	Cream	Orange
1-3	400 (300)[1]	3636 (2727)[2]	265 (199)[2]	78 (59)[2]	35 (27)[2]
4-6	500 (400)[1]	4545 (3636)[2]	331 (265)[2]	97 (78)[2]	43 (35)[2]
7-10	700	6364	463	136	61
10+ (female)	800	7273	530	155	69
10+ (male)	1000	9091	662	194	87

Source: Carey, et al. (1999).

[1]RDA according to Food and Nutrition Board, 2001

[2]Values in parenthesis refer to amount (g) of sweet potato needed to meet the RDAs according to Food and Nutrition Board

Incorporating flour made from OFSP roots into buns, chapattis and mandazis enrich the products in total carotenoids from 0.1 to 2.3 beta-carotene equivalents per 100g product. Results of this study suggest that increased consumption of OFSP in either fresh or processed form can contribute in alleviating dietary deficiency of vitamin A (Hagenimana et al., 1998). Consumption of this carotenoid-rich sweet potato can have a similar effect as the massive-dose capsules, which have been distributed as a main strategy of combating VAD (Kennedy and Oniango, 1993; Rahmathullah et al., 1990). Increasing consumption of the OFSP can, therefore, provide sustainable, cost-effective source of vitamin A to the rural poor families, who do not adequately and regularly access supplements given to alleviate VAD due to poor infrastructure in most remote areas of the developing world (Hagenimana et al., 1998).

3.0 STUDY SETTING AND RESEARCH METHODOLOGY

3.1 Study setting

3.1.1 Geographical location and area

Rumuruti is one of the 6 divisions of Laikipia district, namely Central, Lamuria, Mukogondo, Nyahururu, Ol-Moran, Ng'arua and Rumuruti itself. The division covers an area of 2,786 Km^2 and consists of six locations, namely Marmanet and Muthengera locations which lie in the high-potential parts of Laikipia; and Rumuruti, Mutara, Salaama and Sosian locations in the drier parts. Appendix II shows the location of Laikipia district in Kenya and the different livelihood zones in the district.

3.1.2 Population

The total population of Rumuruti division is 271,720 people. This comprises of 136,371 males and 135,349 females. Rumuruti division has a total of 51,946 house holds, (reported by District Officer, Rumuruti Division).

3.1.3 Climatic conditions

The area has a cool, temperate climate with both rainy and dry seasons. Long rains occur in March to May and short rains in October to November (James and Etim, 1999).

3.1.4 Economic activities

Agriculture is the major economic activity in Rumuruti. Most people are small-scale farmers while others are squatters and landless. The main food crops are maize, beans, tomatoes, peas and onions. Cash crops are wheat, barley and oats (James and Etim, 1999). Ranching is another major economic activity practiced in the ranching zones of Rumuruti location. Other major economic activities are trading, fishing which is done in several dams found in the division, though on small scale.

3.1.5 Ethnicity

The Kikuyu community forms about 60% of population in Laikipia district with the balance composed of other ethnic communities, including Mukogodo Masaai, Samburu, Meru, Borana, Kalenjin, Somali and Turkana. This gives the district a diverse population.

3.1.6 Education

Insecurity remains a major threat to schooling in Laikipia especially in Ol Moran, Rumuruti and Mukogodo divisions which are inhabited by pastoralists. Repeated cattle rustling incidents have caused instability in settlements within these areas, with the parents opting to move away with their children. Such a scenario led to closure of one school: Tigamara primary school in Rumuruti division. The division faces the highest primary school drop-out rate, reaching 26 boys and 181 girls in Term I 2008, as compared to 150 boys and 90 girls in Ol Moran division; no drop-out reported in any of the other divisions.

3.1.7 Nutrition and dietary diversity

Monitoring only the under five children attending health facility, a Kenya Food Security Steering Group short rains assessment reported malnutrition rate in Laikipia district for the period July to December 2007 as 6.4%. Although these figures have not exceeded the emergency threshold and may still be much better compared to the WHO levels for both severe and acute malnutrition and global acute malnutrition, decisions should be made based on the fact that health facilities are thinly spread and probably only a small proportion of U5s attend health facilities. This has also contributed to prolonged morbidity and subsequent increase in mortality rates (KFSSG, 2008).

Earlier on, a case study in 1999 had confirmed malnutrition in about 66% of the households as a major problem. Consumption of food in these households lacked the required calories, proteins and vitamins. The statistics revealed that only about 10% of those below 6 years were near normal status of nutrition (James and Etim, 1999).

Dry whole maize, beans, maize meal and potatoes remain the top common food commodities in the kitchens of most households of Laikipia district. These foods are accessed in the market or home grown. Green vegetables are also available from own gardens or in markets (KFSSG, 2008).

3.1.8 Agriculture

Farm sizes range from one to 10 hectares, which makes small scale farming in the district significant. However, many of the ranches from which these farms are carved were used for extensive livestock production and are thus not suitable for rain-fed agriculture (Mucuthi, 2005).

3.1.9 Immunization and vitamin A supplementation coverage

Vitamin A supplementation coverage was reported to be very low at the time of KFSSG assessment: at 25% in 2008, compared to the similar period in 2005 (70%) and 2006 (50%). Vitamin A supplementation has in the past enjoyed support from UNICEF in both training and organizing supplementation days, but this had not taken place by the time of the assessment, hence the low coverage. Coverage for immunization was also low in Rumuruti division: at 57% as compared to the other divisions, whose coverage range from 63% to 79%, since they are served by full-time mobile clinic e.g. Dol dol area in Mukogodo division has 79.5% coverage (KFSSG, 2008).

3.1.10 Mortality and morbidity

The top five recorded morbidity in Laikipia are respiratory tract infections (RTIs), malaria, pneumonia, diarrhea and intestinal worms. Others are eye infections, urinary tract infections, HIV&AIDS, pneumonia and burns and accidents. Causes of mortality in the district are recorded as HIV&AIDS, pneumonia, pulmonary tuberculosis, malaria and gastroenteritis. Others in that order are RTIs, anemia, typhoid fever and diabetes (KFSSG, 2008). The assessment did not include the figures for the morbidity and mortality rates.

3.1.11 Water and sanitation

The level of water scarcity and its impact on food security is high especially in pastoralist zones (northern and eastern parts of the district). It is in alert levels for the division. Latrines coverage in Laikipia is about 60%. Other methods of human waste disposal include bush method, municipal sewerage system and cat method.

3.2 Study design

A cross-sectional survey with descriptive and analytical components was used to collect information about vitamin A status of children aged between 25-60 months, their feeding patterns as well as production and consumption of sweet potatoes in the households.

3.3 Sampling

3.3.1 Sample-size determination

The sample size was determined using the requirements for detecting rates exceeding the relevant prevalence criterion for assessing night blindness in children between 2-5 years at specified anticipated prevalence in the community (see table 5). A sample of 216 children was required, using an anticipated prevalence of 1.75% night blindness. Adding 5% attrition have a sample size of 227 i.e. 216*1.05=226.8 (**227**).

3.3.2 Sampling procedure

Rumuruti division was purposively selected for the study. Three out of its six locations were also purposively selected: the other three being inaccessible and sparsely populated[1]. In the three study locations (see Figure 2), visits to the chiefs' offices in each location were made to get names of sub locations. The sub locations were listed, then one sub location from each of the locations chosen randomly. The number of children from each of the sub locations was then determined proportionately to the population size of the U5s, as follows:

ΣU5s= 1861 (Siron) +1789 (Muthengera) +1547 (Rumuruti) =5197

Sample size from each sub location:

Siron: 1861*227/5197=81

Muthengera: 1789*227/5197=78

Rumuruti: 1547*227/5197=68

Total: 81+78+68 =**227**

When there was more than one child in a household within the target age group, one was selected randomly.

3.3.3 Inclusion and exclusion criteria

Children within the target age group of 25-60 months in all households in a cluster were assessed. In cases where a household had more than one target child, one child was randomly selected by a secret ballot through the mother/caretaker. A child who was

[1] Reported by the District Officer, Rumuruti division

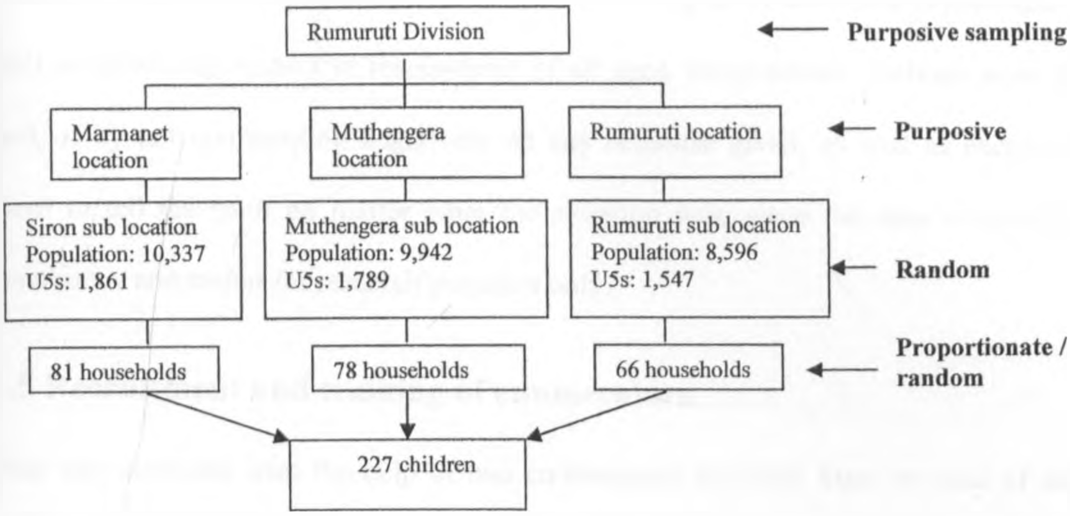

Figure 2: Sampling schema for the survey

absent from home and had been away for the last seven days was excluded from the survey. Also excluded was any child who had been sick such that their feeding patterns were different from the normal.

3.4 Ethical and human rights consideration

Permission to carry out the research was sought by acquiring a letter of recognition from the Dean, University of Nairobi. This letter would be used to obtain permission to carry out research in the study area from local government authorities. Chiefs and village elders were notified of the intention to carry out the research. The letter of recognition from the university would further be approved through signing/stamping by the chief in each sub location visited, and was used for identification and to convince respondents every time there was a problem during the field work.

Verbal consent was sought from the parent(s) before the mother/caretaker was interviewed. Data collection in the households was kept confidential, and the welfare of the respondents was considered all the time: not forcing those unwilling to participate, as well as upholding respect to respondents of all ages. Respondents' feelings were taken care of by not commenting negatively on any response given, as well as encouraging them to tell the truth no matter what the situation was, since the data collected was unanimous and meant for research purposes only.

3.5 Recruitment and training of enumerators

Data was collected with the help of two enumerators recruited from the area of study. They were required to have a minimum of secondary school education. Using an earlier developed training curriculum (Appendix III), the enumerators were given 2-day training, after which they were able to apply skillful interviewing techniques and uphold research ethics during data collection. The training also made the enumerators conversant with the questionnaire aspects, including socio-demographic and socioeconomic data, food frequency, 24-hour recall, night blindness assessment and sweet potato production and consumption patterns.

3. 6 Data collection tools, techniques and procedures

A semi-structured questionnaire (Appendix IV) was used to collect the required information. The questionnaire was pre-tested in five households which were not part of the study population, after which necessary corrections were made. Both qualitative and quantitative data was collected using the questionnaire, a key-informant and a focus group discussion.

3.6.1 Questionnaire

The following data were collected using the questionnaire:

Socio-demography

Socio-demographic information collected included age, sex, gender, education level of household members, as well as main source of livelihood.

Food frequency

The food frequency questionnaire was used as a qualitative method of assessing the risk of VAD among the children. The enumerator would read out from a list of vitamin A-rich foods, and let the respondent state how many days the index child had consumed each item in the last 7 days.

24-Hour recall

Information on amount of food consumed by the index child in the last 24 hours was collected using a 24-hour recall on a sub sample of 32 children who were randomly selected. This sample size was adequate to indicate a representative sample in a population. The data was obtained using volumetric estimates of quantities consumed. Enumerators were carefully trained and carried containers marked in milliliters. For ingredients such as rice and flour, the person who had prepared the food was asked to demonstrate how much she used of each ingredient, using her own container or other method (e.g. handfuls). Then the enumerator transferred that amount into a container to estimate volume. In some cases, amounts prepared were determined by the cost of the ingredients (if bought), after which a market survey was done to approximate the amounts from the cost indicated by the respondents.

Worm infestation

In order to determine if a child had worm infestation at the time of survey, the mother/ caretaker was asked if the child had shown any signs/symptoms of worms. These included a combination of signs/symptoms of a range of the most common worms. To make sure that the respondent was able to give accurate information regarding worm infestation, they were made to understand the range of signs/ symptoms that, if one or more was present, then the child was considered to be infested: itching and irritation of anus or vagina, digestive disorders (pinworm/ threadworm); worm present in stool (tapeworm); craving to eat soil (hookworm); appetite loss, worm passed in stool (roundworm). It is however to be noted that if the child had been de-wormed within the last three months, the child was considered not infested. Patterns of de-worming for the children were therefore inquired in this assessment.

Vitamin A supplementation

This question aimed at finding out the coverage of vitamin a supplementation in the study children and also to determine those to be assessed for night blindness (XN).

Night blindness assessment

The assessment for XN among the study children was done following the WHO (1996) recommended procedure, whereby a series of questions were asked on the child's seeing ability. First it was established if the child had received vitamin A supplementation within the last 6 months. If they had received, they were excluded from the assessment.

Sweet potato production and consumption

An assessment was done to find out the production and frequency of consumption of sweet potatoes by the households. This aimed at establishing the extent of sweet potato production in the study area i.e. amount of land on which sweet potatoes are grown and whether this land was owned or rented, as well as how frequently the sweet potatoes are consumed in the area. In order to establish the amount of sweet potato normally consumed by the children, mothers in the FGD were asked how much sweet potato an average child aged 2-5 years would consume in one sitting. To determine the amount, they were asked to demonstrate the size of sweet potato using a stone. After an agreement on the several sizes given, an average size was taken and a similar size of the sweet potato weighed to get the amount.

3.6.2 Key informant interview

A key informant interview (Appendix V) was conducted whereby a nutritionist from a district hospital situated in Rumuruti Township was interviewed. The aim was to find out the coverage of vitamin A supplementation in children less than five years of age in the last six months. This was for purposes of comparing the two sources of information about vitamin A supplementation (the other source being the survey respondents), as well as finding out whether night blindness had been reported in children in any recent past.

3.6.3 Focus group discussion

Before the assessment of XN, a preliminary study was done by conducting a focus group discussion (FGD) involving 12 women (mothers) aged between 45 to 60 years old to find out if the community was aware of night blindness, and whether a local name for the condition existed. The discussion also aimed at finding out the food crops locally produced in the area and determine amount of sweet potato normally consumed by children 2-5 years. Appendix VI shows the FGD guide that was used for the discussion.

3. 7 Data management and analysis

3.7.1 Data quality control

In order to obtain reliable data, a questionnaire with easy-to-understand, clear questions was designed. The enumerators were properly trained to ensure correct interpretation of the questions as well as proper filling-in of the questionnaire. A pre-test was done to verify the relevance of the questions in achieving the objectives as well as make the enumerators more conversant with the data collection exercise. After the pretest, arising matters requiring attention were addressed for either clarification of their meaning or correction, as well as adding or deleting of questions, as was deemed necessary. The modified questionnaire was used to collect data.

Supervision was done on the enumerators by the principal researcher. A team leader was chosen to assist in overseeing data collection when there would be two teams. After each day's work, a brief meeting was held where all questionnaires were checked to ensure they were completely filled, and necessary corrections were made, with clarifications from the enumerator concerned where necessary. Enumerators were also able to share the problems and challenges encountered, creating room for advice/ recommendations for actions to take in future.

3.7.2 Data entry and cleaning

Data entry into the computer was done through Microsoft Excel, after which it was transferred to SPSS and Epi-Info programs for analysis. Vitamin A Intake Calculator was used to enter the 24-hour data before it was transferred to Epi-Info for analysis. Data cleaning was carried out to ensure that actual information was entered into the computer, and recoding was done for different analyses.

3.7.3 Data analysis

The analysis basically involved interpreting the statistical software outputs into objective-oriented conclusions. SPSS program was used to perform different analyses including descriptive analysis (mean, frequencies, graphs, cross tabulations, percentages and ratios); parametric test (t-test to compare means on continuous data) and non-parametric test (Chi-square) on categorical data. Odds ratio tests were performed using Epi-Info program to determine the likelihood of expressing a certain condition given exposure to some risk. Spearman's Correlation was also done to determine the association between some household characteristics and vitamin A intake in children.

4.0 RESULTS

Introduction

This study examined one biological indicator of VAD (night blindness) and five of a composite of demographic and ecological factors: nutrition and diet-related indicators (qualitative and semi-quantitative measures of vitamin A intake); illness-related indicator (worm infestation) and socioeconomic indicators (maternal literacy and household income). This chapter presents results on vitamin A situation in children and household production and consumption of sweet potatoes by households in the study area.

4.1 Demographic characteristics and socio-economic status

The assessment covered 227 households with a total of 1219 persons and mean household size of 5.4 (±1.8). Sex distribution of the population was 51.8% females and 48.2% males. A total of 227 children: 50.2% girls and 49.8% boys were assessed. Table 10 shows a summary of selected demographic characteristics of the study households. It was found that majority of the household heads were casual laborers, while only a few household heads were found to be permanently employed; unemployment for household heads was negligible in this area. There was a significant relationship between sex of household heads and their occupation (Kruskal-wallis χ^2=12.55, p≤0.05). Spearman's chi square test also showed a significant relationship between sex of household head and income earned (χ^2=0.27, p≤0.05).

Figure 3 shows the distribution of education level of the community members by sex. A chi-square test done revealed that males had a significantly higher education level as compared to females (Spearman's χ^2=21.95, P≤0.05). An assessment of maternal literacy showed that 82% mothers/caregivers were literate. Maternal illiteracy was at 14% while 4% of mothers had achieved only lower primary education (see Figure 4).

Table 10: Selected socio-demographic characteristics of households

Characteristics	N	%
Total households	227	100
Household size (mean)	5.37	_
Age distribution (years)	**1219**	**100**
0-1	64	5.3
2-5	303	24.9
6-17	374	30.7
18-45	454	37.3
55+	24	2.0
Sex of household head	**227**	**100**
Male	180	79.3
Female	47	20.7
Main occupation of household head	**227**	**100**
Farmer	46	20.3
Employed/salaried	31	13.7
Student	1	0.4
Petty business	16	7.0
Businessman/woman	22	9.7
Casual laborer	87	38.3
Unemployed	2	0.9
Pastoralist	7	3.1
Agro pastoralist	2	0.9
Main source of livelihood	**227**	**100**
Sale of farm produce (crop)	24	10.6
Mixed farming: animal & crop sale	18	7.9
Business	20	8.8
Petty business	19	8.4
Casual labor	100	44.1
Salaries	33	14.5
Gifts/donations	6	2.6
Pastoral farming	5	2.2
Agro pastoral	2	0.9
Education level of household head	**1219**	**100**
Not attended school at all	24	10.6
Completed class 1-4 (lower primary)	11	4.8
Completed class 5-7	48	21.1
Completed primary school	77	33.9
Completed secondary school	55	24.2
Post secondary	12	5.3

The socio-economic status was determined by establishing the income each household survived on. It was found that 86.3% of the households were surviving on less than 1 US dollar per person per day. The mean daily income was KSh. 37.80 (±29.99).

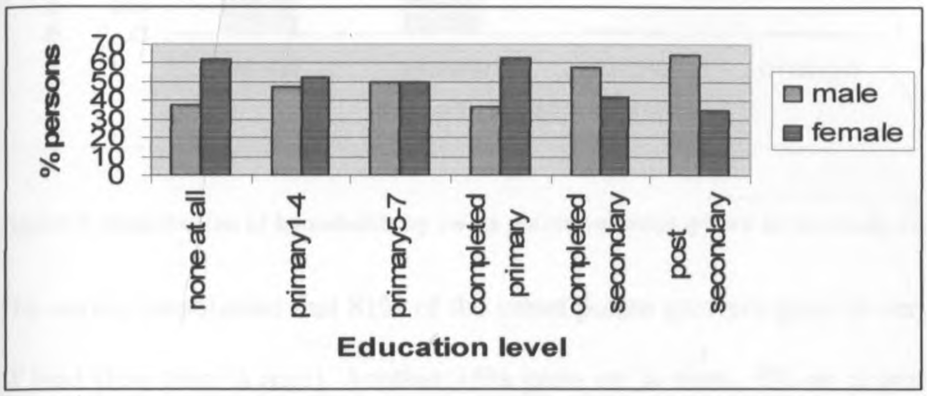

Figure 3: Distribution of persons by sex and education level

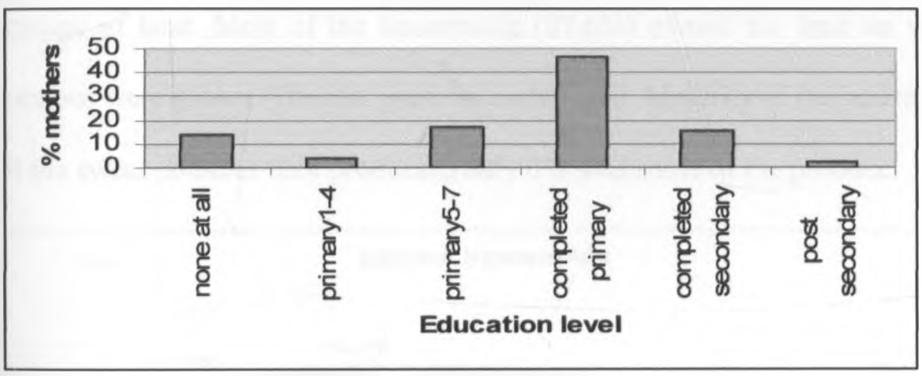

Figure 4: Distribution of mothers by level education

4.2 Household production and consumption of sweet potatoes

The study revealed that 42.7% of the households grew sweet potatoes. Figure 5 shows the distribution of the households by different varieties of sweet potatoes grown in the area.

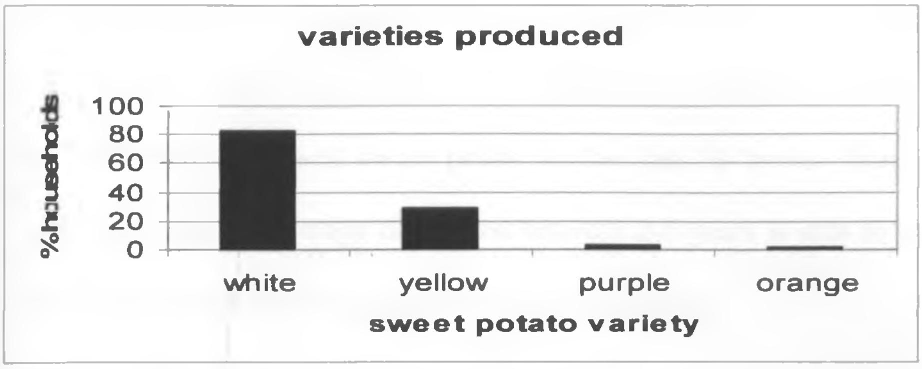

Figure 5: Distribution of households by sweet potato varieties grown in the study area

The survey established that 81% of the sweet potato growers grew in very small portions of land (less than ¼ acre). Another 15% grew on ¼ acres, 3% on ½ acres and 1% on 1 acre. Figure 6 shows the distribution of sweet potato production in the households by acreage of land. Most of the households (87.6%) owned the land on which the sweet potatoes were grown. The rest grew on rented land. Majority of the households consumed all the sweet potatoes they produced; only 6% sold some of the produce.

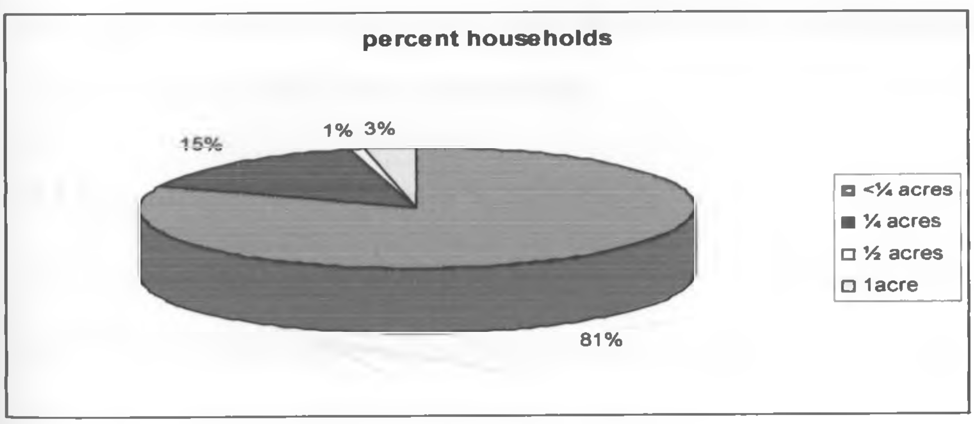

Figure 6: Distribution of sweet potato production in households by acreage

Considering the consumption patterns, Table 11 shows that less than 50% of the population studied had consumed sweet potatoes in the last seven days. A negligible proportion had consumed sweet potato adequately in the week, with only 3% having consumed in at least 3 days in a week. The variety consumed by most people was the white-fleshed, while the remaining percentage had consumed the yellow-fleshed variety. No child had consumed sweet potato in the last 24 hours. From the FGD, it was established that an average child aged between 2-5 years is able to consume a medium sized sweet potato weighing at least 100g in one sitting.

Table 11: Distribution of households by sweet potato production and consumption

Characteristics	Percent households
Growing sweet potato	42
Owning sweet potato plots	87
Consumed sweet potato in the last 7 days	24
Consumed sweet potato in at least 3 days in the week	3

An odds ratio test indicated that the frequency of sweet potato consumption by children did not depend on the amount of land on which the sweet potato were grown (OR 2.0, CI $_{0.31-12.80}$, Fisher exact p-value=0.39). It also did not depend on the household income (OR 1.43, CI $_{0.41-14.50}$, Fisher exact p-value=0.58).

4.3 Consumption of vitamin A-rich foods

The assessment done to find out the 7-days' frequency of consumption of vitamin A-rich foods showed that majority of the children did not consume most vitamin A-rich foods, as shown in table 12. Most of those who consumed animal sources of vitamin A ate for less than 3 days in a week. Only dark green leafy vegetables were highly consumed by more than 75% of children in this community.

Table 12: Frequency of consumption of vitamin A-rich foods in 7-Days

Food item	Had not consumed (%)	Had consumed (%)	<3days (%)	≥3 days (%)
DGLVs[1]	9.3	90.7	11.4	79.3
Beef	39.2	60.8	39.7	21.1
Milk	52.4	47.6	20.3	27.3
Eggs	59.5	40.5	31.3	9.2
Carrots	71.8	28.2	14.1	14.1
Pumpkin	84.1	15.9	10.5	5.4
Mango	84.6	15.4	11.4	4.0
Chicken	88.1	11.9	10.2	1.7
Pawpaw	91.2	8.8	16.3	2.5
Liver	93.2	7.0	6.6	0.4
Ghee	95.6	4.4	0.0	4.4
Fish	95.2	4.8	4.4	0.4
OFSP[2]	98.2	1.3	0.8	0.5

[1]dark green leafy vegetables [2]orange-fleshed sweet potato

The top three vitamin A-rich foods mostly consumed were dark-green leafy vegetables, beef and thirdly milk. Among the most poorly consumed foods were mango, chicken, pawpaw, liver, fish, traditional ghee and OFSP. Supportive information collected through the FGD on food crops produced in the area showed that most of these vitamin A-rich foods were not produced in the study area. The foods mostly grown in the area were: maize, beans, wheat, peas, potatoes and vegetables (kales, spinach), while those less widely produced were: oranges, avocado, sugarcane, sweet potatoes, yams, cassava, arrow root, black beans, pumpkin, courgettes, carrots and water melon.

Odds ratio tests on the most consumed foods indicated that maternal literacy did not affect the frequency of consumption of milk and beef, but it affected that of DGLVs: a child with a literate mother was less likely to consume DGLVs for 3 days or more in a week (Table 13).

Table 13: Consumption frequency of consumption of milk, beef and DGLVs given maternal literacy

Characteristics			OR	C.I	P-value
N=108	Milk				
	≥3dys/week	<3dys/week			
Mother literate	44	57	1.93	0.36-10.42	0.36
Illiterate	2	5			
N=138	Beef				
	≥3dys/week	<3dys/week			
Mother literate	82	43	1.19	0.37-3.87	0.49
Illiterate	8	5			
N=208	DGLVs				
	≥3dys/week	<3dys/week			
Mother literate	16	166	0.13	0.05-0.35	0.00
Illiterate	10	14			

Similarly, household income was found to have no influence on frequency of consumption of milk, beef DGLVs and eggs, but it influenced carrot consumption: a child from a household surviving on <US$1/day was more likely to consume carrots for more than 3 days in a week (see Table 14).

Correlation coefficients showed that frequency of consumption of vitamin A-rich foods was not dependent on household income, except for carrots: households surviving on less than US$1/dayconsumed carrots more frequently than households surviving on US$1/day or more. Table 15 shows combined results of 2-by-2 tables for each of the food items,

Table 14: Consumption frequency of consumption of milk, beef and DGLVs given household income

Characteristics				OR	CI	P-value
	N=107	Milk				
		≥3dys/week	<3dys/week			
Income	≥1USD	6	17	0.39	0.14-1.08	0.06
	<1USD	40	44			
	N=138	Beef				
		≥3dys/week	<3dys/week			
Income	≥1USD	13	11	0.57	0.23-1.39	0.16
	<1USD	77	37			
	N=205	DGLVs				
		≥3dys/week	<3dys/week			
Income	≥1USD	2	27	0.49	0.11-2.21	0.28
	<1USD	23	153			
	N=91	Egg				
		≥3dys/week	<3dys/week			
Income	≥1USD	10	6	0.42	0.13-1.33	0.12
	<1USD	60	15			
	N=63	Carrots				
		≥3dys/week	<3dys/week			
Income	≥1USD	1	13	0.05	0.01-0.40	0.00
	<1USD	30	19			

correlating household income and frequency of consumption of these foods. There was a negative correlation between household's socio economic status and frequency of consumption of carrots, milk, eggs, beef, pumpkin and dark-green leafy vegetables while a positive correlation existed between household income and frequency of consumption of fish, chicken, liver, mangoes and papaya.

Table 15: Spearman's correlations on household socio-economic status and frequency of consumption of vitamin A-rich foods

	Milk		Fish		Eggs		Beef		Chicken		Liver		Carrot		Mango		Pumpkin		Papaya		DGLVs	
Frequency	1[1]	2[2]	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Income 1[3]	6	17	2	0	10	6	13	11	4	0	6	0	1	13	7	2	3	4	4	1	2	27
%	26.1	73.9	100	0	62.5	37.5	54.2	45.8	100	0	100	0	17.1	92.9	77.8	22.2	42.9	57.1	80	20	6.9	93.1
2[4]	40	44	8	2	60	15	77	37	19	4	9	1	30	19	19	7	21	8	10	5	23	153
%	47.6	52.4	80	20	80	20	67.5	32.5	82.6	17.4	90	10	61.2	38.8	73.1	26.9	72.4	27.6	66.7	33.3	13.1	86.9
	r=-.18 p=.07		r=.20 p=.53		r=-.16 p=.13		r=-.11 p=.21		r=.17 p=.39		r=.20 p=.46		r=-.45 p=.00		r=.47 p=.79		r=-.25 p=.14		r=.13 p=.59		r=-.07 p=.35	

[1]child has consumed the food item for ≥3days/week

[2]child has consumed food item for <3days/week

[3]household survives on ≥1 US dollar/day

[4]household survives on <1 US dollar/day

4.4 Dietary intake of vitamin A from foods

The results on 24-hour recall showed that among those aged between 25-36 months (RDA= 300 RE), 75% had not achieved the RDA for vitamin A. Among the older age group (RDA=400 RE), 58% did not achieve the RDA. In average, 68% of the children did not meet the RDA in the last 24 hours. Of this group of children, the 25-36 months old group had consumed in average 60.8% of their RDA (mean: 182.8 RE), while the older group had consumed an average of 62.7% (mean: 251 RE) of their RDA. As little as 25 RE was found to have been consumed in the last 24 hours, while the child who had consumed the highest amount had taken 1525 RE, which was from spinach eaten both for lunch and supper. Taking 100g of OFSP (if the 100g of other varieties consumed by child in one sitting) would add an extra 1111RE to the child's vitamin A intake, thus surpass by far the daily requirements. Table 16 shows a calculation of the potential of OFSP to increase vitamin A intake, if the white-fleshed sweet potato currently consumed by the children was replaced by OFSP.

Table 1615: Potential of orange-fleshed sweet potato in increasing vitamin A intake of children

Age group (Months)	RDA (RE)	% RDA of current vitamin A intake	Grams/RE of sweet potato taken	% RDA if OFSP were taken
25-36	300	60.8%	100g (1111RE)	370%
37-60	400	62.7%	100g (1111RE)	285%

Odds ratio test (Table 17) indicated that both maternal literacy and household socio-economic status did not determine the amount of vitamin A taken by child, hence were not factors in having the child meet the RDA for vitamin A.

Table 17: Dietary intake of vitamin A given maternal literacy and household income

				OR	C.I	P-value
	N=32	Child met RDA				
		Yes	No			
Maternal literacy	literate	21	7	9	0.80-101.16	0.08
	illiterate	1	3			
	N=32	Child met RDA				
		Yes	No			
Household income	≥1USD	1	2	0.19	0.01-2.40	0.20
	<1USD	21	8			

4.5 Prevalence of night blindness

The FGD conducted to establish community awareness of night blindness revealed that the community members were aware of night blindness that manifests itself as blurred vision at low light: the local name referring to the condition is "*marundurundu*". Of the 227 children, 95.2% had received vitamin A supplements, and were therefore not assessed. This figure is a little lower than the figure given by a key informant interviewer (Nutritionist in Rumuruti District Hospital) who reported that vitamin A supplementation coverage was as high as 98% which was realized through the house-to-house visits conducted by polio campaigners two months before the survey was conducted. During these visits, every child under five years old was given vitamin A capsules in addition to the polio vaccine.

Only 4.8% children were eligible for the night blindness assessment and upon assessment, no night blindness was found in any of these children. A close investigation was done on them with view of finding out if they were getting enough dietary vitamin

A. The 7-day food frequency assessment showed that all these children had consumed vitamin A-rich foods for at least three days/week, and mostly they had consumed animal sources of the vitamin.

4.6 worm infestation

The results of the assessment showed that 15% of the children were infested (fig. 7). Of these, 47% were boys, the remaining being girls. There was no significant relationship between worm infestation and age of the child (Spearman's χ^2=0.43, p>0.05).

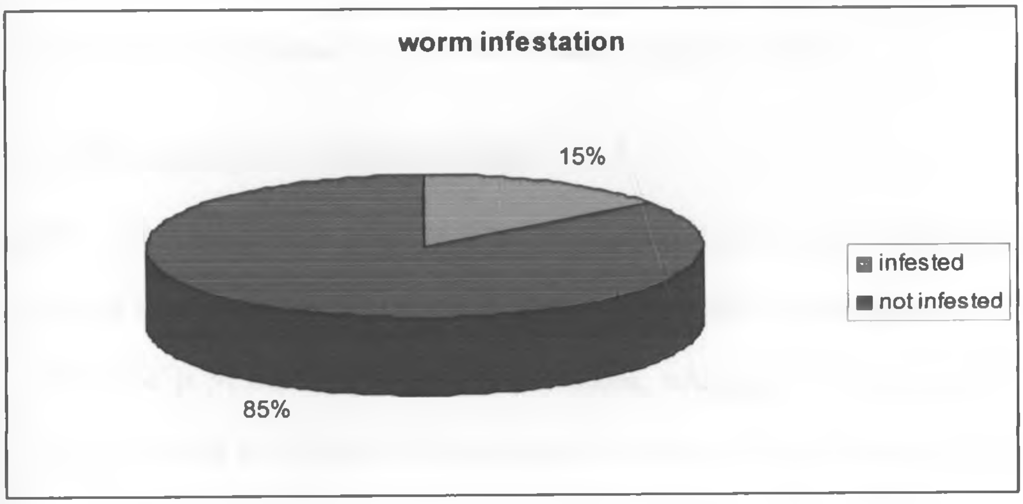

Figure 7: Distribution of the children by worm infestation

5.0 DISCUSSIONS

This section discusses the results on these assessments, giving a picture of the VAD situation in the area. There is a public health problem of VAD when one biological indicator of deficiency is supported by at least four (two of which are nutrition and diet-related) of a composite of demographic and ecological factors (WHO, 1996). Sweet potato production and consumption patterns are also discussed to demonstrate what contribution sweet potatoes have towards vitamin A intake by the children, with a view to determining the potential of OFSP in increasing vitamin A intake.

5.1 Demographic characteristics

The results indicate that the mean household size in Rumuruti (at 5.4) is larger than in an average Kenyan household, of 4.4 persons (CBS, 2004). Sex distribution in the general population is 51.8% females and 48.2% males, while that of the assessed children is 50.2% girls and 49.8% boys. These figures are not very much different from that of the general Kenyan population; with 51% females and 49% males (CBS, 2004). There are variations in education attainment and occupation between males and females. Males have attained higher education as compared to their female counterparts. This has implications in terms of employment opportunities and, therefore, economic dependence. Lower education may limit mothers' exposure to general information, such as nutrition knowledge to offer the best food for their children's optimal growth and health. In 2003 KDHS, a positive relationship between education attainment and exposure to information through mass media is well illustrated (CBS, 2004). For example, women with no education or some primary education are less likely to have access to some forms of media as compared to those who have attained secondary and tertiary education (CBS, 2004). Maternal literacy is an important indicator for assessing VAD risk in children (WHO, 1996). The results show that children in this community do not face a high VAD risk because maternal illiteracy, being at 14%, is above the cut-off point of 50%.

The socio-economic status of the majority is low: 86.3% of the households have low income levels and survive on less than the recommended poverty cut-off of 1 US dollar per person per day. This is far much below the recommended cut-off; it has been indicated that a community is free of VAD risk if less than 50% of the population is spending more than 70% of their income on food (WHO 1996). A household that survives on less than 1 US dollar per person per day is more likely to spend 100% income on food, which may still not be enough. It is also to be noted that the male headed households are generally earning more income. This obviously results from the higher education level of males, thus better paying jobs compared to their female counterparts.

5.2 Household production and consumption of sweet potatoes

From the survey it is evident that majority of the population has not embraced inclusion of sweet potatoes in their farming systems. Those who are growing have done so in very small plots of land, and it is doubtful whether this level of production can make a difference in their meal plan if they decided to include sweet potatoes in their diets for at least three days in a week. This is also probably the reason why most households do not sell any sweet potatoes: they produce too little to have any excess produce that they can sell. These findings create a different picture from what has been documented, with Kenya being rated as one of the largest sweet potato growers in Africa (Benjamin, 2007).

However, majority of the farmers own the land on which they grow the crop, hence there is a potential for sustainable production of the crop. It is also evident that the OFSP has not found its way into the farming systems of this community.

The results also reveal that sweet potato consumption is very uncommon in the area; it does not form a major part of diets, and the majority of those who consume eat the white-fleshed variety, definitely because it is the one available. If, however, they had consumed the OFSP variety, a child who consumed sweet potato for three days in the week would take more than enough vitamin A. Since it was found that an average child would be able to consume about 100g of sweet potato in one sitting, consuming this amount for three days would meet their RDA and an excess stored in the liver (or under the skin if the beta-carotene is unconverted to vitamin A) to take care of 10 more days with no vitamin A consumption from any source. Consuming the same amount for one day in a week would meet the RDA and have an excess stored to take care of two more days with no vitamin A consumption.

5.3 Consumption of vitamin A-rich foods

Foods of animal origin, whose vitamin A is in a biologically active form and of higher bioavailability, are generally poorly consumed by children in Rumuruti. Majority of the children consume mostly DGLVs as their source of vitamin A. This is an issue of concern because bioconversion of plant carotenoids depends on several extrinsic and intrinsic factors in the child, including vitamin A status of the child, vitamin A intake and consumption of lipids.

Frequency of consumption of carrots, milk, eggs, beef, pumpkin and dark-green leafy vegetables does not depend on household socio-economic status. The frequency of consumption of these foods reduces with increasing income, hence, the more income a household earns, the less frequently these foods are consumed. The foods, as would be expected, are locally produced in the area (results from FGD). This is opposed to fish, chicken, liver, mangoes and papaya, since these foods are consumed more frequently by households of higher socio-economic status. This is expected because mangoes and papaya are not locally produced in Rumuruti. Chicken are locally produced but it is not clear why households of higher socio-economic status are consuming more of these than their poorer counterparts. May be they are rearing more chicken to afford more frequent consumption. As for liver, the major source would be purchasing, hence the richer households would definitely afford more frequently. There is, however, no difference between frequency of consumption of these foods and household socio-economic status (whether living in poverty or not), except for carrots. Households living in poverty are consuming carrots more frequently than households that are economically stable. It is therefore possible that carrots are not viewed as an important part of meals by the economically stable households. It is possible that the crop is a means of payment in kind to members of poorer households after working on richer people's farms.

5.4 Dietary intake of vitamin A from foods

The 24-Hr dietary intake study indicates that vitamin A intake for majority of the children is inadequate. Therefore, it is true to say that the adequate vitamin A status observed in the children is due to capsule supplementation. Hence, in the absence of effective and sustained policies and programs for the control of VAD, 68.7% of the children remain at high risk of VAD. Some children would have to survive with as little as 25 RE/day (the amount for the child with the least vitamin A in 24 hours from the survey). Income is not a factor in vitamin A intake of the children.

5.5 Potential of OFSP to increase vitamin A intake

Given that the amount easily consumed by an average child in Rumuruti, mostly for breakfast, is 100g, taking one medium OFSP weighing 100g would add an extra 1142 RE (or 571 RE for 50% bioavailability) to the diet of the child who had the lowest vitamin A intake, increasing the amount of intake to 1167 RE. This meets 389% of the child's RDA (or 198% at the lowest bioavailability levels). For the child with the highest vitamin A intake (1525 RE), taking the same amount of sweet potato would raise the intake to 698% of the RDA (at 50% bioavailability). This shows that, even at the lowest possible bioavailability levels, adding 100g OFSP to the children's diets would ensure intake of vitamin A far much above the RDA, yet safe from toxicity. In other words, the RDA for the children can be met from sweet potatoes alone: a child aged 25-36 months old would require only 27g of sweet potato to get the required RDA of 300 RE, while one aged 37-60 months old would require 35g of sweet potato to get 400 RE. In contrast, taking the same amount of white-fleshed sweet potato would provide only 11 RE while yellow-fleshed variety would provide 150 RE to the child. This could even be lower considering the varying bioavailability levels.

5.6 Prevalence of night blindness

Due to the high coverage for vitamin A supplementation, XN was not assessed in 95.2% of the children. Because the children were being visited in their homes, majority of them were consequently reached and hence able to receive the vitamin A supplementation in the polio campaign period, which was only 2 months before the study was carried out. This therefore led to exclusion of this large number of children from XN assessment. Though this is such a high coverage, it is not usually the case; in 2008, coverage was only 25%. This is therefore an issue of concern considering the fact that polio campaigns are irregular events, which are only carried out in selected districts of Kenya whenever there is an outbreak of polio. It therefore remains that there is a risk of VAD given the low coverage for vitamin A supplementation. Given that the remaining 4.8% children (who did not receive supplementation) are consuming vitamin A-rich foods regularly enough, it is therefore right to conclude that they are getting enough dietary vitamin A to meet body requirements despite having not received vitamin A supplementation, and this is why none of them has night blindness.

5.7 Worm infestation

Worm infestation is an important factor in the absorption of vitamin A from food ingested, and children who are infested are at a high risk of VAD since the worms take up some or all the vitamin A the child gets from food. The results indicate that this community is not at a high risk of VAD given that worm infection prevalence among the study children (at 15%) is above the 50% cut-off point.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the findings of this study, it can be concluded that sweet potato is not an important part of diets in Rumuruti although sweet potato production is practiced in the area. The orange-fleshed sweet potato variety is not popular to farmers in Rumuruti and only a very small proportion of the population is growing the varieties.

No night blindness was found in the children because of the high coverage for vitamin A capsules supplementation. This, however, does not represent the real situation of VAD in Rumuruti because such high coverage is not always the case: it was due to the post polio eradication campaign, which is not a regular event (only occurs when a polio case has been reported). If UNICEF funding was therefore absent, then it means that even the low coverage for vitamin A supplementation which is normally achieved would not be realized.

Majority of the children were found to have inadequate vitamin A intake from foods: they consumed all animal foods for less than 3 days in a week, and plant sources of vitamin A except dark green leafy vegetables for less than 3 days in a week. About 68.7% of the children had not met their RDA for vitamin A in the last 24 hours.

Worm infestation was low and does not pose a threat to the absorption of vitamin A by children in Rumuruti. Introduction of OFSP in Rumuruti and consumption by the U5s would provide sufficient of vitamin A. consumption of as little as 100g OFSP per day by the children would result in intake of vitamin A far above their RDA.

6.2 Recommendations

In order to contribute towards increased production and consumption of OFSPs so as to provide local and cheap source of vitamin A for the children and the community at large, there is need for CIP (Kenya) and its partner organizations to collaborate with the personnel in the agricultural sector to promote the OFSP variety in the area so that it can be a local source of vitamin A for the community.

Because of the constraint that the study faced during assessing XN in the children, there is need for a similar sturdy to be carried out at a time when no such high coverage for vitamin A supplementation has occurred, or rather a study on children of the age bracket that is not targeted for the supplementation. This way it will be possible to find out the real situation of VAD in Rumuruti.

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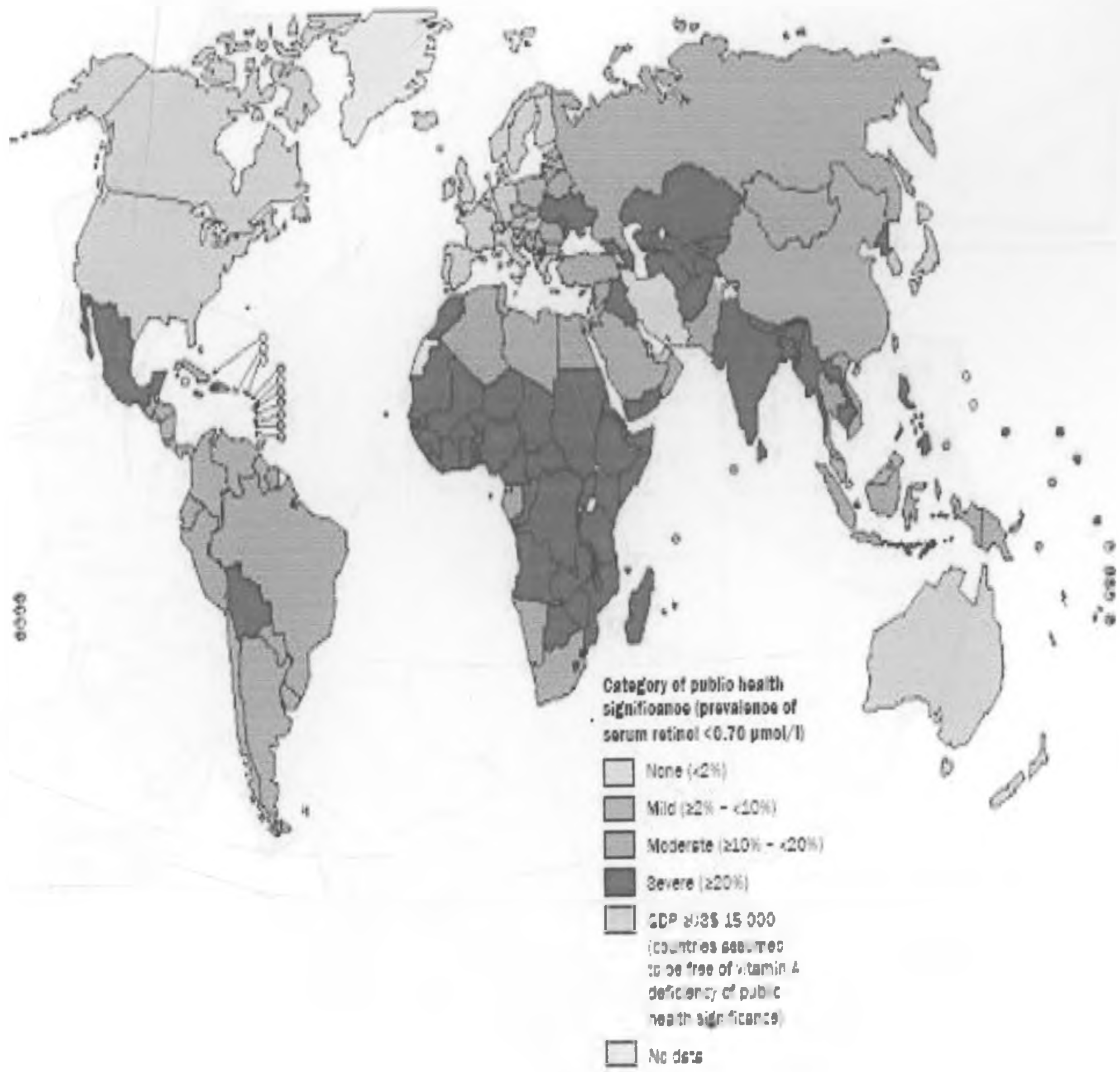
APPENDICES

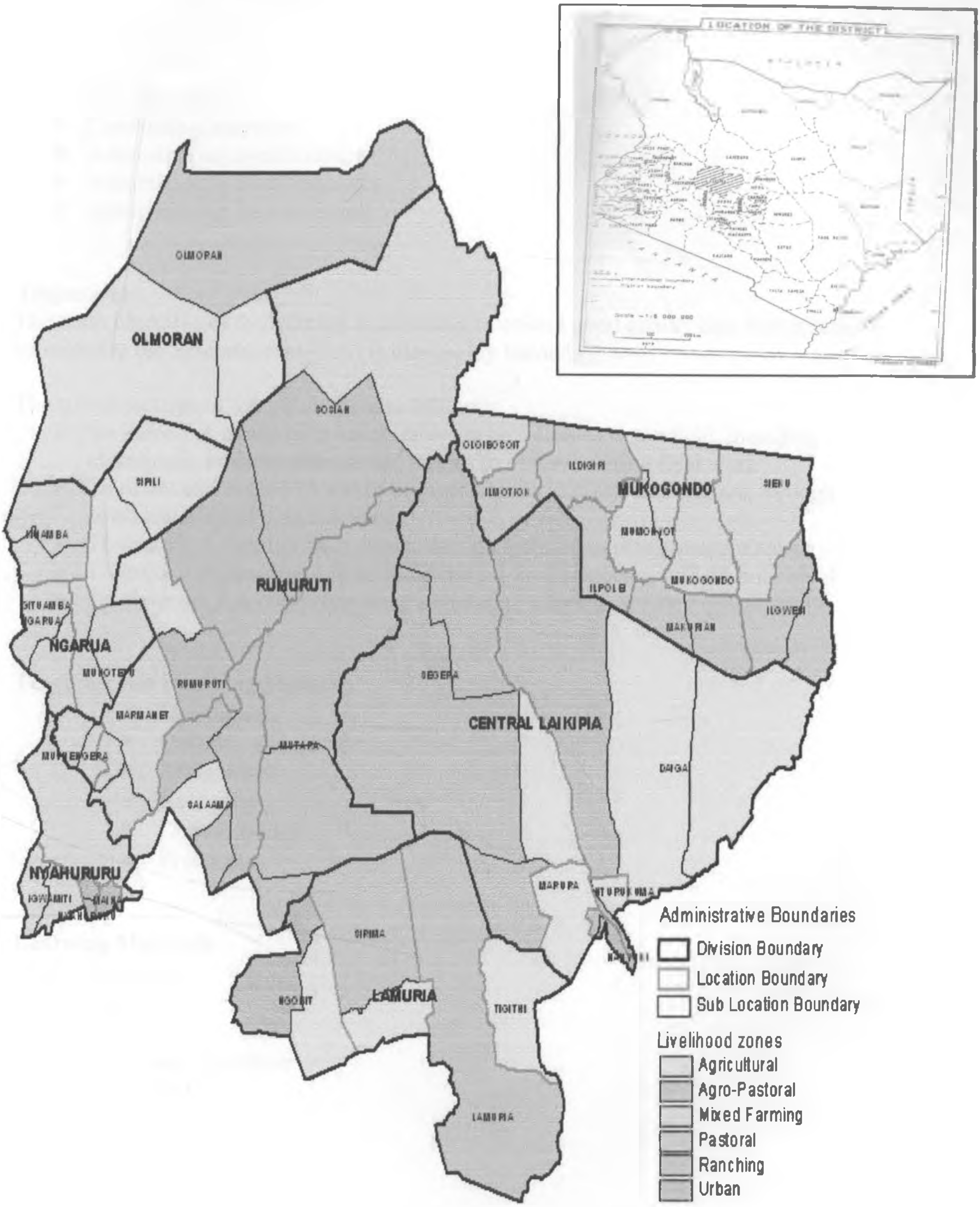
Appendix I: Global prevalence of VAD

Countries and areas with survey data and regression-based estimates: Pre-school age children



Source: World Health Organization, 2009

Appendix II: Map of Laikipia district and livelihood zones



Appendix III: Training module for enumerators

Topics:

- ➢ Research ethics
- ➢ Conducting interview
- ➢ Administering questionnaire
- ➢ Administering food frequency
- ➢ Administering 24-hour recall

Objectives

The main objective of the training is to be able to collect good quality data that is reliable by ensuring the field assistant (F.A) is thoroughly trained.

The sub-objectives of the training are as follows:

- ➢ To make F.A aware of research ethics to be followed in the field, including cleanliness, positive attitude and morals to observe during field work
- ➢ To orient and make F.A aware of respondent's interests and welfare, through confidentiality of data collected
- ➢ To make F.A familiar with data collection techniques using questionnaire
- ➢ To make F.A competent in administering a food frequency and 24-hour recall
- ➢ To make the F.A competent in administering a food frequency questionnaire

Teaching and Learning Methods

- One on one
- Question and answer
- Assignment
- Role p[lay
- Demonstration
- Practical

Learning Materials

- Notebook
- Pen
- Pencil
- Household measures
- Hand outs

Appendix IV: Questionnaire

Questionnaire No._________

UNIVERSITY OF NAIROBI,

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND TECHNOLOGY
APPLIED HUMAN NUTRITION PROGRAMME

Hello, my name is ______________________. On behalf of Jedidah Kihara who is currently a student at the University of Nairobi pursuing Masters degree in Applied Human Nutrition, we are conducting a survey on vitamin A deficiency and sweet potato consumption in children between 2-5 years old in this division.

I order to collect this information, your household has been selected. I would like to ask you some questions related to food intake, income sources and sources of food for this household.

The information you provide will be useful to find out the vitamin A adequacy through food intake in this household an the report findings may be submitted to the community leaders.

All the information you give will be confidential, and will be used to prepare general report. No specific name you give will appear, so there will be no way to identify that you are the one who gave the information.

I also wish to let you know that the information I am looking for will be much more helpful if there is a child aged between 2-5 years old in your household.

I will be grateful if you participate in this survey.

If you have any question you are free to ask now.

Respondent agreed to be interviewed_____________ 1=Yes 0=No

Date __________________________

Household number___ Location__________ Sub location________Village________

Name of respondent_________________ Name of interviewer_____________

Team No.___________ Name of team leader__________________________

SECTION A: DEMOGRAPHIC INFORMATION

Qn. 1. I would like to ask you questions about the people in this household. Please tell me the details of all the people whom you share the same pot with, every day.

SN	Name	Age yrs	Sex	RHHH	Education level	Occupation
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						

Codes:

Sex	**RHHH**	**Education level**	**Occupation**
1-Male	1-head	1-N/A	1-employed
2-Female	2-wife	2-none at all	2-casual labor
	3-son	3-completed primary	3-unemployed
	4-daughter	4-completed secondary	4-student
	5-grandchild	5-post secondary	5-petty business
	6-other (specify)	6-attending primary	6-business
		7-attending secondary	7-farmer
			8-housewife/farmer
			9-housewife
			10-N/A

Qn 2. What is the household's main source of income (Livelihood)?

1-pastoral	6- businessman
2-agro-pastoral	7- petty business
3-mixed farming	8-sale of farm produce
4-formal employment	9-Other (specify)
5-casual labour	

SECTION B: SOCIO-ECONOMIC STATUS

QN. 3: Please indicate; **how much do you earn per year (or per month if employed) for each of your livelihood sources?**

Serial number	Livelihood source	Income per year	Income per month if employed/casual

SECTION C: CHILD INFORMATION

Qn 4. Has _________ (name of child) been infested with worms in the last 2 months? (you may have noted worms in feces or child scratching anal area)

1=Yes 0=No

Qn 5. Has _________ (name) received any vitamin A capsules in the last 6 months?

1=Yes 0=No

Qn 6 (a) Does (name) have any problem seeing in the day time?

1=Yes 0=No

(b) Does (name) have any problem seeing at night time?

1=Yes 0=No

(c) If Yes to 4(b), is this problem different from other children in your community?

1=Yes 0=No

d) Does (child) always bump onto objects while walking in dim light?

1=Yes 0=No

(d) Does (name) have night blindness? (Use local term which describes the symptom)

1=Yes 0=No

SECTION C: SWEET POTATO PRODUCTION/ CONSUMPTION

Qn. 7a) Do you grow sweet potatoes? 1- Yes 0-No

b) If you do, which ones? 1-White-fleshed 2-Yellow-fleshed 3-Orange-fleshed

c) What is the acreage of land under sweet potatoes? 1-< 1 acre 2->/=1 acre

d) Who owns the land in which you plant the sweet potatoes?

1-Own 2-Rented

e) Do the family members consume all sweet potatoes grown?

1-Yes 0-No

f) If no to (e), what is done with the sweet potato not consumed?

1-Sell 2-Feed animals

g) Have the household members consumed sweet potato in the last 7 days?

1-Yes 2-No

h) If yes, what variety was consumed? 1-white-fleshed 2-yellow-fleshed 3-orange-fleshed 4-purple-fleshed

SECTION D: FOOD FREQUENCY QUESTIONNAIRE

Qn. 7 Please indicate; how many times in the last 7 days did__________ (ref child) eat each of the food I list? (Explain to the mother that you want the no. of days, not the no. of times)

	Name of food	**No. of days the food was consumed**	**Source of food** **1-produced** **2-purchased** **3-other(specify)**
1	Whole milk		
2	Fish		
3	Eggs		
4	Chicken		
5	Beef		
6	Liver		
7	Carrots		
8	Ripe mango		
9	Pumpkin		
10	Ripe papaya		
11	Orange flesh sweet potato		
12	Yellow flesh sweet potato		
13	Passion fruit		
14	Avocado		
15	Green leafy vegetables		
16	Ghee (traditional)		

Qn 6. 24-hr Recall for child aged 25-60 months. Now, let us discuss what (name of child) ate yesterday. Starting with the first thing eaten yesterday after getting up, narrate the foods and beverages taken by (ref child) until today morning but not including breakfast **(enumerator should determine if the previous day was normal. If not, another day should be chosen)**

Dish				Ingredients used in preparation								Child consumption			FINAL EXPRESSION		
Time	Description of Dish	Total amt (ml)	Dish code	Description of ingredients	Amt used (ml)	Unit	srce	Size	price		Ing cod	Amnt Servd (ml)	Plate waste	Amount consumed	Weight of ingredients:		
								HH msr	Mkt size	If bought					g	g waste	g consumed

Codes

Time
1=beforebreakfast
2=breakfast
3=btnbreakfastandlunch
4=lunch
5=btnlunchandsupper
6=supper
7=after supper

Unitcodes
1=gm
2=ml
3=kg
4=Lt
5=pcs
6=bunch
7=heap
8=slice
9=loaf

Level:Heaped
21;31=tsp
22;32=tbsp
23;33=tin
24;34=kasuku

Size
1=small
2=medium
3=big
4=verybig
5=1/2kg tin
6=1kg tin
7=1kg kasuku
8=2kg kasuku
9=other(specify)

Source
1=own production
2=bought
3=donation/gift
4=other(specify)

Ingredient code
(separate code list to be prepared)

Appendix V: Key informant interview guide

Topic: Vitamin A Deficiency Prevalence/Vitamin A Supplementation in Children

Key Informant: Nutritionist, Rumuruti District Hospital, Rumuruti Township

Questions to address:

- ✓ Presence of vitamin A deficiency as night blindness/bitots spots among children under five years old in the division (is it a common problem in the area?)
- ✓ Vitamin A supplementation coverage in the children (what is the average coverage?)
- ✓ Methods of assessing VAD (how they assess night blindness, bitots spots)
- ✓ Existence of a local name for night blindness (are they aware of a local name referring to the condition?)

Appendix VI: Focus group discussion question guide

Topic: Vitamin A Deficiency/Sweet Potato Production & Consumption Assessment

Duration: 45 minutes

Introduction:
Introduce self*, note taker and the general purpose of the discussion

Main Discussion

1. What are the sources of livelihood for people in this community?

2. Which foods are mainly produced by people in this area?

3. a) Do people in this area produce sweet potatoes?
   b) If yes, which varieties are there?

4. a) What is the sweet potato used for in this community?
   b) Do children consume sweet potatoes?
   c) What amount of sweet potato is an average child (2-5 yrs) able to consume in one sitting?

5. a) What is vitamin A?
   b) What is its importance in the human body?
   c) What are the food sources of vitamin A?

6. a) What is vitamin A deficiency?
   b) What causes it?

7. a) Have you ever seen/ heard of a night blindness case in children less than five years in this community?
   b) If yes, what is the common name used to refer to the condition?

Conclusion:
Summarize the discussion
Thank and dismiss the participants

Team members: Principle investigator
Observer/ note taker

*self means the principle investigator