Ministry of Health

The Kenya National Micronutrient Survey 2011

Partners

Kenya Medical Research Institute (KEMRI)

Kenya National Bureau of Statistics (KNBS)

Ministry of Health (MoH) – Nutrition and Dietetics Unit (NDU)

National Public Health Laboratory Services (NPHLS)

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Micronutrient Initiative (MI)

Global Alliance for Improved Nutrition (GAIN)

World Food Programme (WFP)

Centre for Disease Control (CDC)

World Health Organisation (WHO)

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Acknowledgements

The Ministry of Health, Nutrition and Dietetics Unit, would like to thank everyone involved in each stage of the Kenya National Micronutrient Survey 2011. This includes the project design, training of data collectors and supervisors, data collection and analysis, and compilation of this final report. The Survey could not have been completed without the support and efforts from the Government of Kenya through the Ministry of Health, KEMRI and KNBS as well as local administration in the various Counties.

Our sincere gratitude goes to partners, including UNICEF, MI, GAIN, WFP, CDC, WHO and Save the Children for their technical, financial and logistical support. We particularly acknowledge the support of late Usha Mudava of CDC who was instrumental in setting up the laboratories and ensuring SOPs were in place to permit quality analysis of biological samples. We thank KEMRI/Wellcome Trust, Kilifi who undertook analyses of blood specimens for Haemoglobinopathies as well as Division of Vaccines and Immunization who provided invaluable support through supply of some of the Nitrogen tanks used in the field.

We appreciate the role played by the former Provincial Directors of Public Health and Sanitation as well as Provincial Administration who included Provincial and District Commissioners, District Officers, Chiefs and Assistant Chiefs for ensuring security and mobilization of communities, provision of motor vehicles and staff to support the field teams.

We appreciate the enormous commitment from the staff of the Centre for Public Health Research, KEMRI which served as the nerve centre of this enormous survey, the staff of Nutrition and Dietetics Unit (formerly Division of Nutrition), MoH and those of Kenya National Bureau of Statistics. Other project staff members who spent many long hours and sleepless nights, and invaluably contributed to the success of this survey are also appreciated.

Most importantly, we wish to recognise and thank the many women, men and children who willingly participated in this study without whom there would be no results to report about. We also give special thanks to all those who participated in the data analysis and report writing processes not forgetting the external consultants who assessed the field activities and reviewed the draft reports for authentication.

A special thanks to the external peer reviewer, Dr James A Berkeley, Centre for Tropical Medicine & Global Health, University of Oxford, UK & KEMRI/Wellcome Trust Research Programme, Kilifi, Kenya.

Gladys Mugambi,
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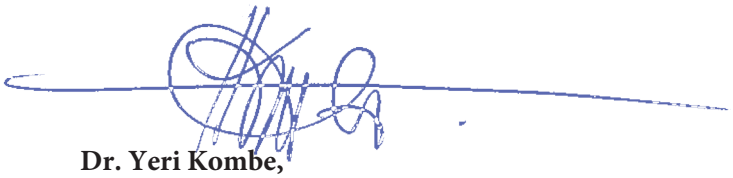
Foreword

In Kenya, like in many developing countries, malnutrition continues to contribute to morbidity and mortality concerns. More than half of the morbidity and mortality cases in children are attributable to malnutrition especially micronutrient deficiencies such as vitamin A, zinc, iodine and iron which are of major public health significance. Currently, Kenya does not have current representative data on micronutrient status for its population at both national and sub-national levels. This position prompted the Government of Kenya, through the then Ministry of Public Health and Sanitation (currently Ministry of Health), to institute the Kenya National Micronutrient Survey (KNMS) in 2011 to generate data on the magnitude and distribution of malnutrition, including micronutrient deficiencies and related disease factors.

The Kenya National Micronutrient Survey 2011 was made possible through a collaborative effort from the Ministry of Health, Kenya Medical Research Institute (KEMRI) and Kenya National Bureau of Statistics (KNBS) with financial and technical support from various partners, including UNICEF, Micronutrient Initiative, Global Alliance For Improved Nutrition, World Food Programme, Centre for Disease Control and World Health Organization. Due to the nature of KNMS, covering both medical and socio-demographic/economic investigations, KEMRI and KNBS as the government lead institutions of the two types of surveys spearheaded its implementation.

Through collective efforts of the government and bilateral institutions, the KNMS met its objective of establishing the prevalence of micronutrient malnutrition and selected infectious diseases related to iron deficiency and anaemia in the Kenyan population. The findings of this survey will provide policy makers and programme managers with the information they need to effectively plan and implement micronutrient interventions.



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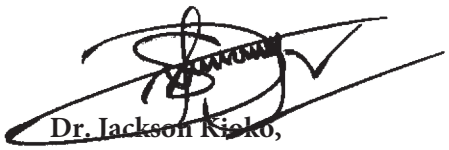
Preface

A micronutrient survey gives the prevalence of micronutrient deficiency status in a population. Periodic surveys are necessary to understand the changes in the nutrition situation and accommodate new information on dietary intake and micronutrients status of the population. Ideally, it is supposed to be conducted after every five years. Due to financial and logistical challenges, this has not been possible in Kenya. The last national micronutrient survey was conducted in 1999. A lot has changed since then as a result of the interventions which have been put in place by the Ministry of Health and other supporting partners. The national data on prevalence of micronutrient deficiencies therefore required to be updated.

A steering committee led by MoH Nutrition Unit and comprising of KEMRI, KNBS and key development and implementing partners as lead members was constituted to plan for a national micronutrient survey and ensure that it was properly implemented. In addition, the steering committee was charged with fundraising for the survey. Alongside this committee, a technical committee led by KEMRI was established which comprised of the technical personnel from MoH, KEMRI and KNBS, in collaboration with UNICEF, MI, CDC, GAIN, WFP and WHO to design and implement the Kenya National Micronutrient Survey.

This report is a synthesis of data collected across all eight regions in Kenya. It provides information on rural and urban distribution of nutrition situation. The report is divided into eleven chapters. Chapter one gives a brief background on the survey and an overall situation of the micronutrient deficiencies in Kenya. Chapter two is on study methods. It gives the details on field work implementation, sample collection, laboratory analysis and quality control and data analysis. Chapter three is on response rates and demographic characteristics of surveyed households. Chapter four gives detailed findings on anthropometric nutritional status while chapter five covers anaemia, iron deficiency, iron deficiency anaemia and associated factors. Vitamin A status is presented in chapter six while Iodine status and zinc status results are presented in chapter seven and eight respectively. Chapter 9 discusses results on folate and vitamin B_{12} deficiency in pregnant and non-pregnant women while food consumption patterns, dietary practices and nutrient intake are presented in chapter 10. The consolidated conclusions and recommendations for the report are presented in Chapter 11.



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Abbreviations and Acronyms

B_{12}	Vitamin B_{12}
B_6	Vitamin B_6
BMI	Body Mass Index
CDC	Centre for Disease Control
CPHR	Centre for Public Health Research
CRP	C-Reactive protein
DBS	Dry Blood Spot
DC	District Commissioner
DO	District Officer
DON	Division of Nutrition
DRIs	Daily Recommended Intakes
DSO	District Statistics Officer
EAs	Enumeration Areas
EDA	Exploratory Data Analysis
EPSEM	Equal Probability Selection Method
ERC	Ethical Review Committee
FD	Folate Deficiency
GAIN	Global Alliance for Improved Nutrition
GDP	Gross Domestic Product
GOK	Government of Kenya
Hb	Haemoglobin
HhH	Household head
Hhs	Households
HIV	Human Immunodeficiency Virus
HPLC	High Performance liquid chromatography
Id	Identity
ID	Iron deficiency
IDA	Iron Deficiency Anaemia
IQ	Intelligent Quotient
IQR	Inter Quartile range
ITNs	Insecticide Treated Nets
KDHS	Kenya Demographic Health Survey

KIE	Kenya Institute of Education
KIHBS	Kenya Integrated Household Budget Survey
KMIS	Kenya Malaria Indicator Survey
KNBS	Kenya National Bureau of Statistics
KNMS	Kenya National Micronutrient Survey
LSC	Laboratory Sub-Committee
LSSC	Logistics, Training, and Supplies Sub-Committee
MCH	Mother Child Health
MDGs	Millennium Development Goals
MI	Micronutrient Initiative
MOH	Ministry of Health
MOPHS	Ministry of Public Health and Sanitation
MOS	Measure Of Size
MOU	Memorandum of Understanding
MUAC	Mid Upper Arm Circumference
NASCOP	National AIDS & STI Control Programme
NASSEP	National Sample Survey and Evaluation Programme
NPHLS	National Public Health Laboratory Services
NPL	Non-Pregnant Lactating
NPNL	Non-Pregnant Non Lactating
NPW	Non-pregnant Women
NSC	National Survey Coordinator
PC	Provincial Commissioner
PCA	Principal Components Analysis
PCR	Polymerase Chain Reaction
PDSC	Protocol Development Sub-Committee of the Scientific Committee
PI	Principal Investigator
PPMOS	Probability Proportional to Measure Of Size
PSC	Pre-School Children
PSUs	Primary Sampling Units
PW	Pregnant Women
QA/QC	Quality Assurance/Quality Control
RBC	Red Blood Cells
RBP	Retinol Binding Proteins

RDTs	Rapid Diagnostic Test
SAC	School Age Children
SD	Standard Deviation
SF	Serum Ferritin
SOPs	Standard Operating Procedure
sTfR	Serum Transferritins
SVI	Swiss Vitamin Institute
UIE	Urinary Iodine Excretion
UNICEF	United Nations Children's Fund
VA	Vitamin A
VAD	Vitamin A Deficiency
VCT	Voluntary Counseling and Testing
WFP	World Food Programme
WRA	Women of Reproductive Age

EXECUTIVE SUMMARY

Background

Malnutrition associated with micronutrient deficiencies (vitamins and minerals) is a major cause of morbidity and mortality, and negatively affects human productivity and economic growth, especially in developing countries. About 45 percent of child deaths and 10 percent of total global disease burden is attributed to maternal and child under nutrition. It is for this reason that improving nutrition has been indicated as the precondition to achieving a number of the Millennium Development Goals. Studies have shown that investing in nutrition can increase a country's Gross Domestic Product (GDP) by at least 2-3 percent each year. Nutrition science in general, and micronutrient science in particular, have continued to gain visibility and to draw attention locally, regionally and internationally. This has continued to shape policies and interventional programs towards improving nutrition in communities. Despite notable nutrition science achievements, many nations in the developing world continue to register grim statistics; many children worldwide die daily from malnutrition while others live through their childhood in a state of chronic malnourishment resulting in unhealthy growth and poor brain development, poor immunity to disease, low IQ, resulting in poor educational performance and reduced quality of life.

In Kenya, like in many developing countries, malnutrition continues to raise morbidity and mortality concerns. Kenya does not have representative micronutrient data at either national or sub-national levels. This position prompted the Government of Kenya, through the Ministry of Public Health and Sanitation (currently Ministry of Health) to institute the Kenya National Micronutrient Survey (KNMS) in 2011to generate data on the magnitude and distribution of micronutrient malnutrition, including nutritional status and a number of related diseases. The aim of the survey was to establish the prevalence of micronutrient deficiencies, protein-energy malnutrition, and infectious diseases among the Kenyan population in order to provide policy makers and programme managers with the information they need to effectively plan and implement micronutrient interventions. Specifically, the survey set out:

(i) To determine the prevalence of wasting, stunting and underweight among children 6-59 months of age and prevalence of thinness and overweight/obesity of women in Kenya;

(ii) To establish the prevalence of anaemia, iron deficiency and iron deficiency anaemia among all population groups in Kenya,

(iii) To determine the magnitude of infection (malaria, parasites, hemoglobinopathies, HIV) and its relation to anaemia among all population groups.

(iv) To determine prevalence of vitamin A deficiency among all population groups in Kenya;

(v) To determine the prevalence of Folate and vitamin B_{12} deficiencies in pregnant and non-pregnant women;

(vi) To determine the prevalence of zinc deficiency in the study population.

(vii) To assess the micronutrient supplementation coverage in Kenya;

(viii) To assess the patterns of household and/or individual dietary consumption and nutrient intake

(ix) To establish the relative roles of salt in ready-to-eat processed foods and of salt consumed in households on the Iodine status of survey respondents;

(x) To determine the prevalence of iodine deficiency in school age children and non-pregnant women

Methodology

The design of KNMS 2011was cross sectional using a two-stage stratified cluster sampling methodology that produced representative estimates for the following three domains: (i) Kenya as a whole; (ii) Rural areas of Kenya; and (iii) Urban areas of Kenya. The sampling frame for the 2011 KNMS was based on the National Sample Survey and Evaluation Programme (NASSEP IV) master sampling frame maintained by the Kenya National Bureau of Statistics (KNBS). The KNMS sample was selected using a stratified two-stage cluster design consisting of 296 clusters, 123 in the urban and 173 in the rural areas. Urban areas were defined as Cities, Municipalities, Town Councils, Urban Councils and all District Headquarters. Rural areas were defined as an isolated large area of an open country in reference to open fields with peoples whose main economic activity was farming. From each cluster 10 households were selected using systematic sampling.

Information related to household characteristics, demographics, socio-economic status, and fortified food consumption was collected at the household level. Salt samples were also collected at the household level. Biological specimens, in the form of venous blood samples were collected from pre-school children aged 6-59 months, children aged 5-14 years, pregnant and non-pregnant women aged 15 to 49 years, and men 15-54 years old within the household. Stool samples were collected from children 6 to 59 months old, children aged 5-14 years, pregnant and non-pregnant women 15 to 49 years old. Urine samples were collected from children 5-14 years old, pregnant and non-pregnant women aged 15 to 49 years. Dietary intake data using the multiple pass 24-hour recall method was conducted in a 20 percent random sub-sample of the households selected for the (2 households in every cluster of 10 KNMS households). The two recall-households were selected only from the households among the 10 KNMS samples that essentially had children between ages 6-59 months and a woman of reproductive age. Where two children of the same category were available, the youngest child was selected.

The sample size required for each stratum was based on the estimated prevalence for each nutritional indicator, the desired precision for each indicator, an assumed design effect of 2.0, and a non-response of 10 percent (including refusals) at the household level, and 10 percent at the individual levels for children 6-59 months of age and non-pregnant women. An additional non-response rate of 10 percent (for a total 30 percent non-response rate) was assumed for the men and school age children (SAC) 5-14 years old. The sample size was determined based on the parameters that required the highest sample size (Zinc, Iodine, Anaemia) for each target group. Fisher's formula for estimating the minimum sample size for prevalence descriptive studies was used. The KNMS survey protocol was reviewed and approved by the KEMRI Scientific and the National/Ethical Review Committee (ERC). As per the national research policies, informed written consent was received from all individuals participating in the survey.

Fourteen teams were involved in KNMS data collection process. Each team comprised of one team leader, one nurse/counsellor, three laboratory technicians, three enumerators and one 24-hour recall research personnel. The teams were trained and the piloting exercise undertaken prior to fieldwork.

The fieldwork for this survey was conducted in 2011 between September and December using various sets of data collection tools. The tools included, household questionnaire, age group specific individual questionnaires, laboratory and anthropometry questionnaire, Kenya Integrated Household Budget Survey (KIHBS) questionnaire and a multiple pass 24-hour dietary intake module. Anthropometric assessments were undertaken on all the study participants followed by collection of biological specimens. The amount of blood collected varied between the subject groups. These samples were processed and stored in line with standard operating procedures for each analyte before being transported to the central laboratory in KEMRI. Strict cold chain procedures were adhered to during the

entire sample collection, processing, storage and transportation periods. The multiple pass 24-hr recall survey was undertaken on 20 percent of pre-school children paired up with their non-pregnant mothers/caretakers aged 15-49 years. To ensure data quality, continuous supervision and review of information was undertaken in-order to identify and correct challenges in real-time. Steps were taken at the central and field level laboratories to improve data quality by implementing quality control procedures and monitoring proficient laboratory analyses.

Field questionnaires were double entered, cleaned and validated prior to analysis. Data comparison was done using Epi-info version 7.0. The datasets were exported into a Statistical Package format (IBM® SPSS® Statistics version 20.0) for analysis. Data merging exercise was systematically conducted using four datasets i.e. household characteristics, individual characteristics, anthropometrics measurements, and laboratory results. CS Dietary (Dietary System Rel 1.11, developed by Harvestplus and SERPRO S.A., Jan 2010) was used to enter the dietary intake data, which were then integrated with the food composition table, recipes database and conversion factors database to yield nutrient intake from each food. The data were exported as a CSV file, and imported into SAS. In SAS the nutrient intake data were summed over each day, for each individual, to give their intakes on the one day. Data merging was conducted in defined steps and the master-files backed-up for safekeeping. All the questionnaires and laboratory forms were filed and stored in lockable drawers, in line with meeting the safety, privacy and confidentiality requirements.

Exploratory data analysis techniques were employed at the initial stage to uncover the distribution structure of the study variables as well as identify outliers or unusually entered values. Distribution of continuous variables was tested for normality using Shapiro-Wilk test. Depending on the distribution, parametric or non-parametric statistical analysis methods were used. Chi-squared or Fisher exact tests were used to test for independence in distribution of different indicators across different categorical variables (demographic characteristics).

Socio-demographic and Economic Characteristics

The average household size was 4.0 + 2 (SD) persons. This compared well with the national findings by KDHS 2008 - 2009 of 4.2 persons per household. When the ages of the household heads (HhH) were grouped into 10 year age categories, the age group of 30 – 39 years contributed the highest proportion (29.0 percent) of HhHs. The sex distribution of household heads showed a significant male dominance (72.4 percent vs. 27.6 percent). Education level of the household head has long been associated with the quality of life. The majority of the household heads (42.4 percent) had attained and completed primary education level with 1.2 percent of the heads having not gone to school at all. From the participating households, the wealth distribution among the five categories showed that 23.2 percent of households were in the highest wealth quintiles. A summary of the results are indicated in table 1.

Nutritional Status

Nationally, the prevalence of stunting, underweight and wasting in the pre-school children was 26.3 percent, 12.7 percent and 6.3 percent respectively. The mean Z score (-1.04 SD) shows an improvement in stunting compared to the means of -1.4 and -1.1 reported in the KDHS 2008-2009 and KDHS 2014.The prevalence of severe stunting was 8.2 percent, higher in rural (9.9 percent) than in urban (3.7 percent) areas. Severe stunting (8.1 percent) was similar to the KDHS 2014 findings. With respect to being overweight and or obese, the overall prevalence among women was 23.9 percent and significantly differed between rural (16.1 percent) and urban (35.1 percent) women.

Anaemia, Iron Deficiency and Iron Deficiency Anaemia

In the study population, the highest prevalence of anaemia, iron deficiency and iron deficiency anaemia was observed in pregnant women at 41.6 percent, 36.1 percent and 26 percent respectively, and lowest in men (9.3 percent, 3.6 percent and 2.9 percent respectively).

Pre-school children had a higher prevalence of anaemia, iron deficiency and iron deficiency anaemia (26.3 percent, 21.8 percent, and 13.3 percent respectively) than school-age children (16.5 percent, 9.4 percent and 4.9 percent respectively). Non-pregnant women on the other hand had a prevalence of 21.9 percent for anaemia, 21.3 percent for iron deficiency and 14.0 percent for iron deficiency anaemia comparable to that of preschool children.

Differences in prevalence of anaemia, iron deficiency and iron deficiency anaemia were noted in different age groups of pre-school children. Level of education of the household head and wealth quintile of the household were found to have a relationship with the anaemia status. While Iron deficiency and anaemia was affected by worm infestation and iron intake.

In school age children, prevalence of anaemia status was affected by residence, while education level of household head and the wealth quintile of households had an effect on anaemia, iron deficiency and iron deficiency anaemia. Anaemia and iron deficiency anaemia were affected by age in non-pregnant women. In pregnant women, anaemia, iron deficiency and iron deficiency anaemia was affected by residence of the respondent.

Vitamin A Deficiency

Vitamin A deficiency (<0.70 µmol/L) was based on retinol-binding protein values in the study population. The crude national prevalence of Vitamin A deficiency (considering the combined sub-populations studied) was 4.1 percent. Pre-school children (PSC) had the highest (9.2 percent) prevalence of Vitamin A deficiency (VAD) compared with all other groups. The marginal VAD (0.7 - <1.05 µmol/L) in PSC was 52.6 percent. Prevalence of overall marginal Vitamin A deficiency was 24.4 percent. The observed prevalence of VAD is also lower compared to the global estimates of 33.3 percent in pre-school children. In pre-schoolers, residence of the children was a main factor associated with occurrence of VAD. Children in rural areas were less likely to be Vitamin A deficient compared to urban residents (prevalence of 8.1percent and 12.1 percent, respectively). Furthermore, sex, level of education and wealth quintiles were not important determinants of VAD in pre-school children.

The prevalence of VAD and marginal VAD among school-aged children was 3.6 percent and 33.9 percent respectively. As observed in Pre-school children, the majority (one third) of children in this age group with marginal deficiency are at risk of VAD. Unlike in the PSC, residence was not a determining factor for VAD but prevalence of VAD decreased with level of education and wealth quintile.

Among pregnant and non-pregnant women, the highest VAD prevalence (5.4 percent) was observed among pregnant women and reduced significantly in the non-pregnant women (1.1 percent). The prevalence of marginal VAD in pregnant and non-pregnant women was 21.6 percent and 8.1 percent respectively. When VAD was considered by the residence of the pregnant women, those in urban areas had a significantly much higher (14.0 percent) deficiency than in those of rural residence (0.0 percent).

Iodine Deficiency

The national iodine deficiency prevalence was 22.1 percent among school age children and 25.6

percent among non-pregnant women. Female children (25.2 percent) had significantly higher levels of iodine deficiency compared to the male (19.1 percent), with 25.0 percent of iodine deficient children in rural areas. Iodine deficiency among non-pregnant women was higher (30.1 percent) in rural than urban (17.9 percent) areas. On the other hand, 30.4 percent of school age children and 25.2 percent of non-pregnant women had excessive iodine levels (more than 300ug/L).

A major source of iodine is iodized salt. Based on the Kenya Salt Iodization Standard (KS 2009) of 30-50ppm, less than a half (48.3 percent) of the salt samples analysed were optimally iodized. Both rural and urban areas had salt with iodine levels less than 30ppm (rural 31.8 percent; urban 25 percent) and above 50ppm (rural 20.9 percent; urban 25 percent). Among school age children, significant differences were found in the mean urinary sodium concentrations by age categories, gender, residence and household wealth status. The older school age children (9 to 14 years) had higher mean urinary sodium concentrations (81.4milimol/L) compared to the younger population at 71.2milimol/L. The mean urinary sodium concentration was higher in male (83.6 percent) than female children (70.3 percent), and among children residing in urban (88.2%) than rural (72.7 percent) areas. Sodium concentrations varied with household wealth quintile, where high sodium concentrations were observed in households from higher wealth quintiles (94.5 percent and 87.0 percent) compared to lower wealth quintiles (72.0 percent and 65.5 percent). Among the non-pregnant women, the younger age group (15 to 19 years) had higher mean urinary sodium concentrations (87.3 percent) compared to women above twenty years (71.2 percent). Non-pregnant women in urban areas had significantly high (81.4 percent) sodium concentrations compared to women in rural areas (69.8%), and so did those in the highest wealth quintile (90.4 percent) compared to the lowest (74.3%) quintile.

Zinc Deficiency

The 2011 National Micronutrient Survey established that pre-school children had the highest prevalence of zinc deficiency (83.3 percent) among all the population subgroups. This was followed by non-pregnant women with a prevalence of 82.3 percent, school age children (80.2 percent), men (74.8 percent) and finally pregnant women (68.3 percent) with the lowest prevalence. The prevalence of zinc deficiency among preschool children, school age children and men was consistently higher among rural dwellers (86 percent, 82.5 percent and 79.7 percent respectively) compared to their urban counterparts (76.4 percent, 73.6 percent and 70 percent respectively). The picture among pregnant women was different, where urban and rural dwellers did not differ significantly in prevalence of zinc deficiency. Prevalence of zinc deficiency was also noted to vary with household wealth quintiles in some of the survey sub-groups in particular pre-schoolers and school age children where lower prevalence's of zinc deficiency were seen in households of higher wealth quintiles (75 percent and 67.7 percent respectively) and higher prevalence's (89 percent and 85.5 percent respectively) in households in the low wealth quintiles. Gender differences in zinc deficiency among school age children were noted where males had higher (83.0 percent) prevalence than females (77.2 percent). The prevalence of zinc deficiency in pregnant women showed an increasing trend with increasing trimester of pregnancy, where women in their 2nd and 3rd trimesters had higher prevalence (69 percent) of zinc deficiency than those in their first trimester (60.7 percent).

It is important to note here that even after correcting for inflammation using the computation procedure described in chapter 2, the prevalence of zinc deficiency showed marginal (largest was 1.4 percent) decreases across all survey groups. Although pregnant women had the lowest prevalence of low serum zinc concentration in

this study, men in general had a higher median serum zinc concentration than the rest of the population groups.

Folate and Vitamin B_{12} Deficiency among women

The national prevalence of folate deficiency in pregnant women was 32.1 percent and 30.9 percent in non-pregnant women. Distribution of folate deficiency in pregnant women showed no significant variability by residence. Pregnant women that dwell in urban areas had a prevalence of 25.0 percent compared to those in rural areas of 36.0 percent. In non-pregnant women, there was no significant difference in the distribution of folate deficiency in terms of age, level of education and wealth quintile. However, significant difference was noted in the prevalence of folate deficiency according to area of residence of non-pregnant women. Non-pregnant women in urban areas had a higher prevalence of folate deficiency (40.6 percent than non-pregnant in rural areas (25.1 percent).

Vitamin B_{12} deficiency in pregnant women was 7.7 percent and 34.7 percent in non-pregnant women. The pregnant women that dwell in rural areas had a higher (8.0 percent) prevalence of Vitamin B_{12} deficiency compared to pregnant women in urban areas (7.1percent). There was no significant difference in the distribution of Vitamin B_{12} deficiency in terms of area of residence and wealth quintile. However, significant difference was noted in the prevalence of folate deficiency according to age, with the highest prevalence observed in women of 15 – 19 years (47 percent) and lowest in women 20 - 49 years (31.5 percent). Significant difference was also noted in the distribution of prevalence of Vitamin B_{12} by level of education with women who have no education having the highest prevalence of Vitamin B_{12} deficiency (45.8 percent) and women with post primary level of education having the lowest prevalence (26.0 percent).

Breastfeeding patterns

Assessment of household patterns and/or individual dietary consumption found that 95.9 percent of the children aged 6-11 months; 61.9 percent aged 12-23 months; 10.7 percent aged 24-35 and 24 percent aged 36-47 months were breastfed the day preceding the survey. The expectation that children be breastfed up to the age of two years was only being achieved among two thirds of the children in that age category. Mothers and caregivers reported that 91.1 percent of the children were ever breastfed. 35.8 percent children were breastfed immediately after delivery, 23.1 percent within an hour, 26 percent after one hour, and 10.9 percent after one day while 4.2 percent did not know. Early initiation of breastfeeding is associated with improved immunity for the child due intake of colostrum.

Micronutrient Supplementation

Information gathered on micronutrient supplementation revealed that at least 84.3 percent of all the children under the age of five years had ever received Vitamin A supplementation while 53.1 percent had received the supplementation 6 months prior to our survey. In 2010, Vitamin A coverage in Kenya (Vitamin A supplementation refers to the percentage of children ages 6-59 months old who received at least two doses of Vitamin A in the previous year) was at 62 percent (KNBS AND ICF Macro, 2010 2010). Among the women of reproductive age with regards to the most recent birth, 34.9 percent were supplemented with Vitamin A immediately after delivery. Care givers reported that 4.7 percent pre-schoolers and 2.4 percent school aged children had received or bought iron tablets or pills. However, 29.0 percent of the pre-schoolers and 6.5 percent school aged children were reported as current consumers of soil or earth. 38.1 percent preschool children and 33.5 percent school aged children had received medication for intestinal worms while only 2.8 percent were diagnosed with anaemia.

Dietary and Nutrient Intake

The mean DDS in children was below the recommended cut-off for minimum dietary diversity of at least 4 of the 7 food groups which is associated with better quality for both breastfed and non-breastfed children. Meat based-meals are least consumed by the households in the poorest socio-economic index but the limited protein source appears to be compensated by consumption of more beans and nuts among the poor. Grains were, in fact, important sources of all the micronutrients studied except for vitamin A. Grains are the leading source of iron and zinc, milk and dairy is the leading source of calcium, and vegetables are the leading source of vitamin A.

Notably, high salt consumption was noted by about 90 percent of adults, and two-thirds of children and the amounts were greater in adults than children. Salt consumption appears similar between urban and rural areas compared to sugar where urban individuals consumed more sugar than rural.

Conclusions and Recommendations

Compared to the previous national micronutrient survey results, there is a considerable improvement in the micronutrient status in Kenyan population except for zinc deficiency whose prevalence was higher. This may be attributed to the combined impact of the programs implemented by the Ministry of Health and partners. What requires to be done now is the scaling up of the implementation of high impact nutrition interventions so that further gains can be realized.

Table S: 1: Summary of Key Findings in Kenya National Micronutrient Survey 2011

Indicators	National Prevalence			
	n	%	95% CI	
Nutritional status				
Pre-School Children (Stunting) (children 6-59 months) Height-for-age <-2 SD (Stunting)	1130	26.3	23.7	28.9
Pregnant Women (MUAC <23 cm)	117	11.7	5.9	17.5
Anaemia (based on age specific Hb cut-offs. Hb adjusted for altitude)				
Pre-School Children	827	26.3	23.3	29.3
School Age Children (Children 5-14 years)	872	16.5	14.0	19.0
Pregnant Women	104	41.6	32.1	51.1
Non-pregnant Women	592	21.9	18.57	25.23
Men	240	9.3	5.87	13.33
Iron Deficiency (based on age specific serum ferritin cut-offs. Serum ferritin corrected for inflammation)				
Pre-School Children	918	21.8	19.1	24.5
School Age Children	942	9.4	7.5	11.3
Pregnant Women	111	36.1	27.2	45.0
Non-pregnant Women	633	21.3	18.11	24.49
Men	247	3.6	1.28	5.92
Iron Deficiency Anaemia (based Hb and serum ferritin cut-offs)				
Pre-School Children	827	13.3	11.0	15.6
School Age Children	942	4.9	3.5	6.3
Pregnant Women	104	26.0	17.6	34.4
Non-pregnant Women	592	14.0	11.20	16.80
Men	243	2.9	0.79	5.01
Vitamin A Deficiency (based on RBP cut-offs)				
Pre-School Children	918	9.2	7.3	11.1
School Age Children	942	4.7	3.4	6.1
Pregnant Women	111	5.4	1.2	9.6
Non-pregnant Women	632	2.0	0.9	3.1
Men	111	0.0	0	0
Folate Deficiency				
Pregnant Women	78	32.1	21.7	42.5
Non-pregnant Women	445	30.9	26.6	35.2
Vitamin B_{12} Deficiency				
Pregnant Women	78	7.7	1.8	13.6
Non-pregnant Women	445	34.7	30.3	39.1
Zinc Deficiency (Serum zinc corrected for inflammation)				
Pre-School Children	711	81.6	78.8	84.5
School Age Children	901	79.0	76.3	81.7
Pregnant Women	109	67.9	59.1	76.7
Non-pregnant Women	617	79.9	76.7	83.1
Men	239	77.4	72.1	82.7
Iodine Deficiency				
School age Children	951	22.1	19.5	24.7
Non-pregnant Women	623	25.6	22.2	29.0

CHAPTER 1: INTRODUCTION

1.1 Introduction

Malnutrition is a serious problem affecting over two billion people worldwide. It increases susceptibility to infections and exacerbates their severity. It is thus the most important risk factor for illness and death in developing countries. The underlying determinants of malnutrition are multi-factorial (e.g., the political and economic environment, level of education and sanitation, food intake and breast-feeding habits, prevalence of infectious diseases, availability and quality of health services).

Malnutrition, specifically under nutrition, is typically classified as protein-energy malnutrition and micronutrient deficiency. Although sometimes not apparent, micronutrient deficiency, or "hidden hunger", is regarded as a significant contributor to the global burden of disease. Specifically, micronutrient deficiencies of Vitamin A, Zinc, Iodine and Iron are recognized worldwide as of public health concern (Bhutta ZA, et al 2008). Research has shown that deficiencies of vitamins and minerals have important health consequences, both through their direct effects, such as iron deficiency anaemia, xerophthalmia due to vitamin A deficiency, and iodine deficiency disorders, and because they increase the risk of serious infectious (Lancet 2013) Micronutrients are essential for human health but currently, there is scarce data in countries faced with high-burden of deficiencies.

1.2 Malnutrition in Kenya

In Kenya, Iron, Vitamin A, Iodine, Folate, B_{12}, and Zinc are micronutrients known to be of public health importance, though recent national data are scarce. According to the IDA report of 1999, 48 percent of women of reproductive age (15- 49 years), 55.1 percent of pregnant women, 69 percent of children, and 31.4 percent of men and school age boys were found to be anaemic (either mild, moderate or severe) (Dary, 2009). Iron deficiency in children was 19.5 percent (serum ferritin <12µg/L), which is most likely an underestimate because inflammation was not accounted for in the analysis. In women, 28.6 percent had serum ferritin levels below 12µg/L and an additional 14.6 percent had a level between 12-20µg/L. Among children and women, severe Vitamin A deficiency (serum retinol <0.35µmol/L) was 24.2 percent and 10.3 percent respectively. Additionally, marginal vitamin A deficiency (levels of 0.7 to <1.05µmol/L) was 60.2 percent in children and 40.4 percent in women. Approximately 50 percent of both children and women had serum Zinc levels below 65µg/L. It should be noted that the national data estimates were based on purposive rather than a randomly selected sample (Benoist et al., 2002). Little is known about vitamin B_{12} and Folate deficiencies in the Kenya population.

Iodine deficiency surveys undertaken in 1994 and 2004 show that the prevalence of goitre among children aged 8-10 years had decreased from 16 percent to 6 percent respectively (Stoltzfus, 2003; Dror and Allen., 2008). Though the reduction in prevalence of goitre is attributed to the consumption of iodized salt by over 90 percent of Kenyan households (Sazawal, et al 1995), the 2004 survey showed that 25 percent of children had inadequate intake based on their Urinary Iodine Concentration rates (UIC) whilst a large proportion (34 percent) had excess rates above expert recommendations, suggesting a risk of adverse health consequences (Stoltzfus, 2003). Until 2009, the standard for iodine fortification in salt (100ppm) in Kenya was among the highest in the world and was only reduced to 30-50 ppm in 2012 after years of deliberation and regional recommendations.

Local studies have also provided insight into the prevalence of various micronutrient deficiencies. Baseline data from a multi-nutrient powder effectiveness trial of children aged between 6-35 months conducted in Western Kenya in March 2007 by Black et al., (2008) showed that 67 percent of children were anaemic, 44 percent were iron deficient and 13 percent were vitamin A deficient. Table 1.1 below summarizes data on micronutrient deficiencies in Kenya from 1994 to 2007.

Under nutrition is a public health problem in Kenya. According to the 2008 Kenya Demographic Health Survey (KNBS AND ICF Macro, 2010), 35.3 percent of Kenyan children under-five years of age were stunted. Trends show that there has been an increase in the national stunting rates of children from 30 percent in 2003 to 35 percent in 2008, but declined to 26 percent as per the recent KDHS. The highest prevalence has been reported among children between the ages of 18-35 months. At the sub-national level, Nairobi had the lowest (28.5 percent), while Eastern Province had the highest prevalence (41.9 percent); Coast Province recorded prevalence of 39.1 percent, and Western Province, 34.2 percent. At the national level the prevalence of wasting in children was 6.7 percent, and mostly so in the North Eastern Province (19.5 percent). Each of these nutritional indicators was slightly higher among boys than girls and more in rural compared to urban children. In women, the prevalence of obesity (BMI > 25) was higher than thinness (BMI <18.5), (25.1 percent and 12.3 percent, respectively) according to the 2008-2009 KDHS. In North Eastern Province, a reverse pattern was observed with a prevalence of (11.4 percent) obesity and (26.4 percent) thinness. There was higher prevalence of thinness in younger women and obesity in older women.

1.3 Interventions to combat malnutrition in Kenya

In Kenya, despite the fact that significant progress has been made in increasing food production and reducing food insecurity in the country over the last thirty years, achieving sustainable food security, for all, remains a challenge. In recognition that malnutrition remains a problem and an obstacle to overall development, the Government of Kenya (GOK) developed a National Food Security and Nutrition Policy and Strategy with the objective of "ensuring that all Kenyans throughout their life-cycle enjoy, at all times, safe food in sufficient quantity and quality to satisfy their nutritional needs for optimal

Table 1.1: Data on micronutrient deficiencies among children 6-59 months old, women of reproductive age and school-age children in Kenya from 1994-2007

Nutrition indicator	1994	1999	2004	2007
Anemia (%)	-	69	-	67*
Iron deficiency (%)	-	20	-	44*
Vitamin A deficiency (%)	-	24	-	13*
Zinc deficiency (%)	-	50	-	-
Women of Reproductive age				
Anemia (%)	-	48	-	-
Iron deficiency (%)	-	29	-	-
Vitamin A deficiency (%)	-	10	-	-
School Age Children				
Inadequate Urinary Iodine Excretion (%)	-	-	24	-
Goiter (%)	16	-	6	-

*Children 6-35 months of age in Western Kenya

health" (Mburu ASW et al., 2010). The policy provides an overarching framework covering all the four dimensions of food security (availability, accessibility, stability and meeting nutritional requirements) and addresses the synergy linking food and nutrition security with poverty reduction. Key strategic interventions related to nutrition include; a) Supplementation of children with vitamin A and expectant women with Iron, and Folate, b) Fortification of salt, wheat flour, maize meal, and vegetable oil, c) Promotion of consumption of nutrient-rich foods.

In supplementation efforts, there have been both routine and accelerated vitamin A supplementation activities for children 6 to 59 months of age and postpartum women within 4 weeks after delivery. Iron and folate supplementation have been implemented in the maternal and child health (MCH) clinic and other health service delivery outlets for pregnant women. With respect to the fortification of staple foods, Kenya has made concrete steps over the past few years to expand the number of food vehicles that are fortified and to expand the production of fortified foods. In 2007, the National Fortification Standards and Food Fortification Logo were launched, prompting the voluntary fortification of wheat flour, maize meal, and vegetable oil by producers. Salt Iodization Standards were revised in 2009; the mandated iodine concentration in salt was decreased based on the evidence that the population was at risk of excessive iodine intake. The largest sugar producer in Kenya began fortifying majority of its sugar with Vitamin A and in 2012; legislation was passed by the Kenyan parliament making it mandatory for industrial producers to fortify wheat flour, maize meal, vegetable oil, and sugar. A reduction of the current micronutrient deficiencies in Kenya would accelerate achievements in key developmental areas of child survival, maternal health and universal primary education, which underlie achievement of the Millennium Development Goals (MDGs).

1.4 Survey Rationale and Objectives

Kenya does not have current representative data at the national level on the prevalence of anaemia and deficiencies of iron, vitamin A, iodine, folate/folic acid, zinc, and vitamin B_{12}. The aim of the 2011 KNMS was to estimate micronutrient deficiencies and their underlying causes in Kenya. There is also a lack of quality monitoring data for large-scale micronutrient interventions and programmes that limits the ability to carry out evidence based programme management decisions. The survey provides baseline data for planning, monitoring and evaluation of fortification and micronutrient supplementation programmes in Kenya. In addition, it will identify how micronutrient deficiencies, infections and haemoglobinopathies contribute to anaemia, and provide direction for implementation of evidence-based interventions for anaemia, and other common nutritional problem in Kenya. Further, the high UIE rates found in 2004 were likely associated with the excessive amounts of iodine in salt, and with the recent reduction in the salt iodine standard, there is a clear need to assess the current iodine status of the Kenyan population and link this to the coverage of household salt iodization, as well as other sources of iodine in the diet (e.g. iodized salt in processed foods, etc.).

1.4.1 General Objective

The general objective of the KNMS was to assess the prevalence of micronutrient deficiencies, under nutrition, associated infectious diseases, and the use of fortified food products by the Kenyan population in order to provide policy makers and programme managers with the information they need to effectively plan and implement micronutrient interventions.

1.4.2 Specific Objectives

- To determine the prevalence of wasting, stunting and underweight among pre-school children (PSC) and prevalence of thinness and overweight/obesity (using BMI) of women in Kenya.
- To determine the prevalence of Anaemia among all population age groups in Kenya.
- To determine the prevalence of Iron deficiency in PSC aged 6-59 months, school age children (SAC) aged 5-14 years, non-pregnant women (NPW) and pregnant (PW) women aged 15-49 years old, and men aged 15-54 years old.
- To establish factors contributing to anaemia among survey respondents.
- To determine the magnitude of infection (malaria, parasites, haemoglobinopathies, HIV) and its relation to anaemia among PSC, SAC, NPW, PW and men.
- To determine the prevalence of Vitamin A deficiency in PSAC, NPW, PW and men.
- To determine the prevalence of Folate deficiency in NPW and PW.
- To determine the prevalence of Vitamin B_{12} deficiency in NPW and PW.
- To assess the national micronutrient supplementation coverage in Kenya.
- To assess the patterns of household and/or individual dietary consumption.
- To establish the roles of salt consumed in households on the Iodine status of survey respondents.
- To determine the prevalence of Iodine deficiency in SAC and NPW.
- To determine the prevalence of Zinc deficiency in PSC, SAC, NPW, PW and men.

CHAPTER TWO: STUDY METHODS

2.1 Study design, sample size and sampling processes

The KNMS 2011/2012 was designed to produce representative estimates for: (i) Kenya as a whole; (ii) rural areas; and (iii) urban areas. It was a cross-sectional stratified cluster survey comprising 296 clusters (123 in urban and 173 in rural areas). From each cluster, a uniform sample of 10 households was selected using the equal probability systematic sampling method. The study population comprised of preschool children aged 6-59 months, children aged 5-14 years, pregnant and non-pregnant women aged 15 to 49 years, and men 15-54 years old within the selected households. The sampling frame for the 2011 KNMS was based on the National Sample Survey and Evaluation Programme (NASSEP IV) master sampling frame maintained by Kenya National Bureau of Statistics (KNBS).

The sample size was based on prior estimates of the parameters (e.g. zinc, iodine, anaemia) for each target group; the desired precision; an assumed design effect of 2.0 and expected non-response rates. Allocation of the sample to the domains was done using the square root adjustment method to ensure valid estimates (Table 2-1), and selection of clusters done using the Equal Probability Selection Method (EPSEM).

Table 2.1: KNMS 2011 Sample Allocation

Domain	Sample Households	Sample clusters
Rural	1,730	173
Urban	1,230	123
National	2,960	296

2.2 Ethical considerations

The KNMS survey protocol was approved by the KEMRI Ethical Review Committee (ERC) and written informed consent was obtained for all individuals participating in the survey. Those tested and found to be severely anaemic, or with malaria were referred to the nearest health facilities for treatment and follow up. Through authorised written consent, the KNMS assessed the HIV status of all the survey participants. Respondents with HIV-positive test results received counselling and were referred for appropriate HIV care and treatment services in the area for follow-up, as per the Kenya Ministry of Health HIV policy guidelines.

2.3 Training and piloting

Each KNMS pre-test survey team had nine members; one team leader, one nurse/counsellor, one household phlebotomist (to collect blood samples from respondents), two cluster laboratory staff, three enumerators and one 24-hour recall staff. Fourteen teams undertook the pre-test survey in the country. The training of staff was conducted at Kenya Institute of Education (KIE) from 18th July to 12th August 2011, that was preceded by a three days (28th -30th June 2011) training of a team by KNBS to update the list of households in the selected clusters. The finalized version of the questionnaire was prepared based on the feedback from the field application during the training period.

The pilot was conducted on, 24th August 2011 in two clusters in Kiambu District about 20km North of Nairobi that represented a rural and an urban cluster, under the close eye of training facilitators.

Piloting for the 24 Hour Recall was done within the Nairobi's Eastland areas, Mathare Valley on the 28th of July 2011 where each trainee had the opportunity to interview a household.

2.4 Data collection

The KNMS fieldwork was conducted from September to December 2011 using household, individual and KIBHS questionnaires, and dietary assessment was undertaken in a cross-section of population in urban and rural areas using the multiple pass 24 hr recall tool. This is a 4-step, 24-hour recall interview technique that greatly enhances the recollection of foods and beverages consumed as well as improve the estimation of food quantities (portion sizes) consumed by the respondent. Anthropometry measurements included of height, length and weight in children, mid-upper arm circumference in both young children (6-59 months) and pregnant women, and weight and height in adults.

This was followed by collection of biological samples (blood, urine and stool). The amount of blood collected varied between the subject groups. Stool and urine samples were collected from women and school aged children. Initial sample processing was done in field laboratories and samples later transported to the central laboratory in KEMRI. Each team was supplied with the proper cold chain storage chambers, which included liquid Nitrogen, -20°C CF 60 fridges, cool boxes, dry ice, battery packs among other supplies.

To ensure data quality, continuous collection and review of information was conducted for the purpose of identifying problems and correction in real-time by quality control teams. Steps were taken at the central and field level to improve data quality by implementing quality control procedures and monitoring proficient laboratory analyses. A team of supervisors and external evaluators were engaged in this process to evaluate the quality of training and field implementation processes.

For individual assays, samples were transferred to various laboratories in Kenya and overseas. Eight laboratories participated in analyzing samples for the KNMS 2011. These were: Centre for Public Health Research, Centre for Biotechnology Research and Development, Centre for Clinical Research, Centre for Virus Research of KEMRI, KEMRI - Welcome Trust in Kilifi, National Public Health Laboratory, DBS-Tech Laboratory in Germany and the Swiss Vitamin A Institute in Switzerland (Table 2-2). Field questionnaires were double-entered, cleaned and validated. Adjustment for altitude and correction for inflammation was done for the haematological indicators. The distribution and structure of variables were examined to identify outliers and errors.

Table 2.2: Biological markers assessed per study population

Pre-SAC (6-59 months)	SAC (5-14 years)	Non-Pregnant Women (15-49 years)	Pregnant Women (15-49 years)	Adult Men (15-54 years)	Household
Anaemia (Hb)	Anaemia (Hb)	Anaemia (Hb)	Anaemia (Hb)	Anaemia (Hb)	Salt Iodine
AGP	AGP	AGP	AGP	AGP	
CRP	CRP	CRP	CRP	CRP	
Retinol Binding Protein (RBP)	Retinol Binding Protein (RBP)	Retinol Binding Protein (RBP)	Retinol Binding Protein (RBP)	Retinol Binding Protein (RBP)	
Serum Ferritin	Serum Ferritin	Serum Ferritin	Serum Ferritin	Serum Ferritin	
sTfR	sTfR	sTfR	sTfR	sTfR	
Haemoglobinopathies	Haemoglobinopathies	Haemoglobinopathies	Haemoglobinopathies	Haemoglobinopathies	
HIV Rapid testing (Voluntary)	Hematuria	Hematuria	Hematuria	HIV Rapid testing (Voluntary)	
Intestinal Parasites (qualitative[1])	HIV Rapid testing (Voluntary)	HIV Rapid testing (Voluntary)	HIV Rapid testing (Voluntary)	Malaria (Rapid testing)	
Intestinal Parasites (quantative[2])	Intestinal Parasites (qualit)	Intestinal Parasites (qualit)	Intestinal Parasites (qualit)	Malaria (Thick smear)	
Malaria (Rapid testing)	Intestinal Parasites (quant)	Intestinal Parasites (quant)	Intestinal Parasites (quant)	HIV - DBS (ELISA)	
Malaria (Thick smear)	Malaria (Rapid testing)	Malaria (Rapid testing)	Malaria (Rapid testing)	Zinc	
Zinc	Presence of S. *haematobium*	Presence of S. *haematobium*	Presence of S. *haematobium*		
HIV - DBS (ELISA)	Malaria (Thick smear)	Malaria (Thick smear)	Malaria (Thick smear)		
HIV - DBS (PCR) (< 18 months)	Urinary Iodine	Urinary Iodine	Urinary Iodine		
	Urinary Sodium	Urinary Sodium	Urinary Sodium		
Plasma Folate	Zinc	Serum Folate	Serum Folate		
Plasma Vitamin B_{12}	HIV - DBS (ELISA)	Vitamin B_{12}	Vitamin B_{12}		
		Zinc	Zinc		
		HIV - DBS (ELISA)	HIV - DBS (ELISA)		

2.5 Adjustment of Haemoglobin Levels for Altitude

To adjust for altitude, an adjustment factor was computed using the following formula:-

Hb adjustment = -0.032 x [altitude (m) x 0.0032808] + 0.022 x [altitude (m) x 0.0032808]2

The haemoglobin values minus adjustment factor resulted in haemoglobin concentration at sea level to enable application of WHO cut-offs for determination of anaemia.

2.6 Correction of RBP, Serum Zinc and Serum Ferritin for Inflammation

Serum-ferritin, serum Zinc and Retinol Binding Protein (RBP) are indicators that are affected by inflammation. Based on concentrations of serum C-Reactive Protein (CRP) and Acid-Glycoprotein (AGP), four inflammation groups were determined, namely: 1,Normal (non elevated) or reference group (CRP ≤5 and AGP ≤1); 2, Incubation (CRP >5 and AGP ≤1); 3, Early convalescence (CRP >5 and AGP >1); and 4, Late convalescence (CRP ≤5 and AGP >1).

1 Described as positive/negative or present/absent
2 Described by total count

The correction factor (CF) for each indicator was defined as the ratio of the median value of the indicator for the reference group to those in groups 2, 3, and 4. Adjusted corrected concentrations of the indicators were calculated by multiplying the individual values by their group-specific CF. These adjusted concentration indicators were used for estimating respective deficiencies.

2.7 Body Mass Index (BMI) for Adult Men and Non-pregnant Women

BMI was computed using a standard formula:

BMI = weight in kilograms / height in meters squared and BMI cut-off points recommended by (WHO 2000) were used in the analyses.

2.8 Anthropometry Computation

Anthropometric indices, weight-for-age, height-for-age and weight-for-height Z scores for pre-school children (PSC) were computed using ENA for SMART programme, which uses the 2007 WHO reference standards.

2.9 Calculation of Wealth index

The wealth index was calculated using data on household's ownership of selected assets. The weights (factor scores) for each of the assets were generated through principal components analysis (PCA). Weights were summed by household and after ranking the total scores, the household were divided into quintiles (each containing 20 percent of the households). Household members acquired the total score and quintile of their household.

(Table 2.3) gives cut-offs for various indicators recommended by WHO (2001) that were used in the analysis.

2.10 Limitations of the Report

This study intended to achieve several objectives among them, 'To determine the Kenyan household coverage in use of fortified food products (salt, flours, oil, sugar) and the level of fortification and labelling of such food'. Although questionnaires relating to this objective were filled and samples of flour, oil and sugar were collected at household level and preserved for laboratory analysis, analysis has, to date, not been undertaken due to financial constraints. Since the laboratory analysis of food samples was intended to corroborate results of the household questionnaire on food fortification and the laboratory data is missing, presenting the questionnaire data alone may be misleading and hence this objective has not been included in this report. In addition it's important to note that HIV prevalence was not a main survey objective, therefore the results on low prevalence in HIV should be interpreted with caution. Consequently, comparison with KAIS might create misinterpretation of the findings especially in pregnant women, whose sample size was small.

Table 2. 3: Cut-off points for various key indicators

Study Group		Anemia Haemoglobin (Hb) in g/dL		Iron Deficiency Serum Ferritin (SF) in µg/L	Iron Deficiency Anemia Haemoglobin & Serum Ferritin
PSC		<11.0		<12	Hb <11.0 & SF <12
SAC	5 – 11 yrs	<11.5		<15	Hb <11.5 & SF <15
	12 – 14 yrs	<12.0		<15	Hb <12.0 & SF <15
PW		<11.0		<15	Hb <11.0 & SF <15
NPW		<12.0		<15	Hb <12.0 & SF <15
Men		<13.0		<15	Hb <13.0 & SF <15
Study Group		**Vitamin A Deficiency Retinol Binding Protein (RBP) in µmol/L**		**Folate Deficiency Serum Folate in nmol/L**	**Vitamin B_{12} Deficiency Serum B_{12} in pmol/L**
		VAD	Marginal		
PSC		<0.70	0.7 - <1.05	-	-
SAC		<0.70	0.7 - <1.05	-	-
PW		<0.70	0.7 - <1.05	<10	<150
NPW		<0.70	0.7 - <1.05	<10	<150
Men		<0.70	0.7 - <1.05	-	-

CHAPTER THREE:
RESPONSE RATES AND DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLDS

3.1. Response rates

The response rate was computed out of the minimum sample size required to estimate a specific indicator without adjustment for non-response. While the sample size attained for pre-school and school age children met or surpassed the minimum sample required for pregnant women and men was often below the minimum sample required for all indicators. Non-pregnant

Table 3. 1: Response rates for various indicators by study group

Population group	Age Group	Minimum sample size [3]	Attained sample size	Response rate[4] (%),
Anaemia status				
Preschool Children	6-59 months	1243	1023	82
School age Children	5-14 years	750	973	130
Non-Pregnant Women	15-49 years	1312	650	50
Pregnant Women[5]	15-49 years	227	117	52
Men	15-54 years	384	264	69
Iron status				
Preschool Children	6-59 months	876	927	106
School age Children	5-14 years	711	964	135
Non-Pregnant Women	15-49 years	1367	647	47
Pregnant Women	15-49 years	227	111	52
Men	15-54 years	248	250	100
Vitamin A status				
Preschool Children	6-59 months	1026	918	89
School age Children	5-14 years	686	942	137
Men	15-54 years	132	257	195
Sickle cell status				
Preschool Children	6-59 months	1026	884	86
Non-Pregnant Women	15-49 years	224	619	276
Thalassaemia status				
Preschool Children	6-59 months	1026	843	82
Non-Pregnant Women	15-49 years	224	596	266
Malaria status				
Preschool Children	6-59 months	1149	856	74
Non-Pregnant Women	15-49 years	876	622	71
HIV status				
Preschool Children	6-59 months	444	912	205
Non-Pregnant Women	15-49 years	557	678	122
Nutritional status				
Preschool Children: Stunting	6-59 months	925	1130	122
Preschool Children: Wasting	6-59 months	1119	1130	101
Non-Pregnant Women	15-49 years	578	695	120

3 The minimum sample size calculations do not factor in the 20% (for women and PSC) and 30% (for men and SAC) inflation for non-response or refusals that was described in the proposal.

4 The minimum sample sizes calculated varied from indicator to indicator. A decision was made to use the sample sizes for the indicators with the highest minimum sample sizes on all indicators whose sample sizes were lower. Hence the observation of some response rates in excess of 100%.

5 The results for this sub group (pregnant women) should be interpreted with caution due to small sample size.

women had response rates of 80 percent and above for sickle cell, thalassemia and HIV status and sample size below 80 percent of the minimum required for anemia, iron and malaria status.

3.2. Demographic characteristics

3.2.1. Residence, Household size, Age and sex

The sampled households totalled 2465. The majority of the households that participated in the KNMS (60.8 percent) resided in the rural areas compared to the estimated original sample size of 58.4 percent of households that would be in rural areas. The average household size of the participating households was 4.0 + 2.0 persons per household. This compares well with the national figure of KDHS 2008-2009 of 4.2 persons per household (KNBS AND ICF Macro, 2010). When the ages of the household heads (HhHs) were grouped into 10 year age group it was noted that the age group of 30 – 39 years contributed the highest proportion (29.0 percent) of HhHs while those aged less than 20 years had the least proportion (0.9 percent) of HhHs. The sex distribution of household heads showed a significant male dominance (72.4 Versus 27.6 percent), which was similar to the reported KDHS, 2008-2009 data (66.1 Versus 33.9 percent).

Table 3. 2: Characteristics of participating households, Kenya 2011

Characteristic	N	%
Age of Household Head		
<20	21	0.9
20 – 29	421	17.2
30 – 39	709	29.0
40 – 49	462	18.9
50 – 59	384	15.7
60 – 69	226	9.2
70 – 79	132	5.4
80 and above	90	3.7
Sex of Household Head		
Male	1783	72.4
Female	681	27.6
Residence		
Rural	1498	60.8
Urban	967	39.2
Head of Household Education		
Preschool	393	15.9
Primary	1080	43.8
Secondary/A Level	702	28.5
College/University	262	10.6
Not Stated	29	1.2
Household Size		
Mean (+ SD)	4 (+ 2)	
TOTAL PARTICIPATING HOUSEHOLDS	**2,465**	

3.2.2. Household Head Education level

Household heads education level has long been associated with the quality of life of the members of the household. From the results, majority of the household heads (42.4 percent) had attained and completed primary education level. Only a few household heads (1.2 percent) had not gone to school or had zero years of schooling.

CHAPTER FOUR: NUTRITIONAL STATUS

4.1. Overview

The nutritional status of children has been described using three indices namely, height for age, weight for age and weight for height. Height-for-age index provides an indicator of linear growth retardation and cumulative growth deficits. Children whose height-for-age Z-score is below minus two standard deviations (-2 SD) from the median of the WHO reference population are considered short for their age (stunted). Children who are below minus three standard deviations (-3 SD) are considered severely stunted. Stunting reflects failure to receive adequate nutrition over a long period and is affected by recurrent and chronic illness. Height-for-age, therefore, represents the long-term effects of malnutrition in a population and is not sensitive to recent, short-term changes in dietary intake.

The weight-for-height index measures body mass in relation to body height or length and describes current nutritional status. Children with Z-scores below minus two standard deviations (-2 SD) are considered thin (wasted) and are acutely malnourished. Wasting represents failure to receive adequate nutrition in the period immediately preceding the survey and may be the result of inadequate food intake or a recent episode of illness causing loss of weight and the onset of malnutrition. Children whose weight-for-height index is below minus three standard deviations (-3 SD) are considered severely wasted. Weight and height was available for 97.0 percent of sampled children.

Weight-for-age is a composite index of height-for-age and weight-for-height. It takes into account both chronic and acute malnutrition. Children whose weight-for-age is below minus two standard deviations (-2 SD) are classified as underweight. Children whose weight-for-age is below minus three standard deviations (-3 SD) are considered severely underweight (WHO, 2007).

4.2. Nutritional Status of Children aged 6-59 months

Nationally, the prevalence of stunting, underweight and wasting in children aged 6-59 months was 26.3 percent, 12.7 percent and 6.3 percent. Table 4-1 indicates the nutrition status of children 6-59 months of age using height for age, weight for age and weight for height.

According to the WHO classification, the national levels of stunting reported in this survey are classified as medium; so is the prevalence underweight and wasting. A reduction in the point prevalence was observed when these results are compared with results of the last Kenya Demographic Health Survey (KNBS AND ICF Macro, 2010, 2010) that reported the prevalence of stunting at 35 percent, while underweight and wasting was 16.7 percent and 6.7 percent respectively. The results are also comparable to the KDHS 2014which reported 26 percent of children are stunted. This trend has been observed in many countries that have reported, stunting rates much higher than their underweight rates (UNICEF, 2009).

4.2.1. Levels of Stunting

In Kenya, stunting remains a problem of greater magnitude than underweight or wasting, and it more accurately reflects nutritional deficiencies and illness that occur during the most critical periods for growth and development in early life (UNICEF, 2009). Stunting is attributable to a wide range of factors including low birth weight, inadequate care and stimulation, insufficient nutrition, recurrent infections, and other environmental determinants (Wamaniet al., 2007). The prevalence of severe stunting which is defined as ≤ 3 standard deviations was 8.2 percent. This was higher in the rural (9.9 percent) than in the urban (3.7 percent) by almost three fold (Table 4-1). Compared to KDHS 2008-2009, there was a reduction in severe stunting from 14.2 percent to 8.2 percent (KNBS AND ICF Macro, 2010,).

Stunting was more pronounced in the rural children (30.0 percent) compared to urban children (16.9 percent), this is similar to the findings from the KDHS 2008-2009. This also concurs with evidence of a review of 36 countries, which showed that the rural children were more malnourished than those in urban areas (Smith *et al*., 2005). These have been associated with the observation that the mothers of children in urban areas are likely to be more educated and with better income therefore improved feeding and care practices and access to better health care for their children (Smith *et al*., 2005).

The age group 6-11 months reported the lowest proportion of stunted children (0.14 percent), while the age group 24-35 months reported the highest proportion of stunted children (33.4 percent), Table 4-1. Infants are expected to be exclusively breastfed[6] from birth to six months, and it is recommended that they begin eating nutritious and adequate solid foods (complementary foods) thereafter with continued breastfeeding through two years of age and beyond. This could explain the lower prevalence of stunting in children aged 6-11 months (0.14 percent), compared to those aged 24-35 months (33.4 percent).

The proportion of boys who were stunted was 27.4 percent compared to girls at26 percent. Ithas been observed in the region, there are gender differentials in stunting based on sex typically with males showing a slightly higher rate of stunting than females (Mukira *et al*, 2005). In several of the surveys reviewed by Mukira *et al*, sex differences in stunting were more pronounced in the lowest socio economic groups in sub-Saharan Africa. Male children under five years of age are more likely to become stunted than females, which might suggest that boys are more vulnerable to health inequalities than girls in the same age groups (Wamani *et al*. 2007).

6 Exclusive breastfeeding means a child is fed on only breastmilk and no other fluids or foods including water

Table 4. 1: Nutritional Status of Children aged 6-59 months by height-for-age, weight-for-height, and weight-for-age

		Height-for-age			Weight-for-height			Weight-for-age		
Characteristic	**n**	**% below -3 SDa**	**% below -2 SDb**	**Mean Z-score (SD)c**	**% below -3 SDa**	**% below -2 SDb**	**Mean Z-score (SD)c**	**% below -3 SDa**	**% below -2 SDb**	**Mean Z-score (SD)c**
Age Group (in months)										
6-11	136	4.0	10.0	-0.46	1,5	3.9	-0.08	3.20	9.10	-0.27
12-23	218	7.9	29.1	-1.14	1.33	7.3	0.05	2.12	14.1	-0.52
24-35	253	8.7	33.4	-1.25	0.9	5.0	-0.04	0.89	12.5	-0.69
36-47	263	10.3	27.9	-1.22	2.6	7.2	-0.17	1.7	15.6	-0.83
48-59	260	7.3	21.3	-0.99	2.2	4.6	-0.26	1.03	10.5	-0.77
Sex										
Male	578	9.70	27.4	-1.11	2.12	6.90	-0.72	1.97	15.06	-0.75
Female	552	6.40	26.0	-0.89	2.00	5.50	-0.84	1.80	9.93	-0.56
Residence										
Rural (1)	788	9.9	30.0	-1.14	1.9	6.0	-0.10	2.3	13.2	-0.71
Urban (2)	342	3.7	16.9	-0.77	2.5	7.06	-0.13	0.99	11.4	-0.52
Wealth Quintile										
Lowest	328	11.00	35.5	-1.30	2.12	8.11	-0.28	3.50	20.1	-0.91
Second	270	8.9	27.8	-1.30	1.74	4.4	0.03	1.11	8.14	-0.70
Middle	201	8.08	28.8	-0.95	2.08	8.63	-0.25	1.46	13.7	-0.72
Fourth	193	6.29	15.5	-0.77	3.12	7.29	-0.13	2.50	12.2	-0.5
Highest	125	2.99	16.4	-0.63	1.73	3.06	0.13	0.31	3.06	-0.26
TOTAL	**1130**	**8.2**	**26.3**	**-1.04**	**2.09**	**6.3**	**-0.11**	**1.91**	**12.7**	**-0.66**

Note: n indicates un-weighted denominators for each subgroup; subgroups that do not sum to the total have missing data.
a) Percentages weighted for non-response and survey design.
b) Includes children who are below -3 standard deviations (SD) from the WHO Child Growth Standards population median
c) CI=confidence interval, adjusted for cluster sampling design.

4.2.2. Levels of Wasting

Wasting is usually due to recent illness and/ or insufficient dietary intake caused by food shortages, feeding practices, or other events. National prevalence of wasting among pre-school children was 6.3 percent this is comparable to6.7 percent reported by KDHS 2008 - 2009. The KDHS 2014 reported a national wasting prevalence of 4 percent. Although the differences between rural and urban residents were not significant, rural children showed a marginally lower (6.0 percent) prevalence of wasting than those of urban residence (7.1 percent). The mean standard deviation Z score for wasting nationally was -0.11 similar to what was reported in KDHS 2008 - 2009 (-0.1SD). Overall prevalence of severe wasting which is defined as ≤3 was found to be 2.09 percent, which was higher in the urban (2.5 percent) than in the rural (1.9 percent) children. The age category differences shown on wasting were found to be highest (7.3 percent) in the 12-23 month and in the 36-47 month olds (7.2 percent).

Wasting in children increases from the period of introduction of solid foods (age six months) through the second year of life. Research in Kenya shows children are introduced to complimentary feeding even before six month of age, however mothers who have received information on optimal feeding practices are more likely to introduce complimentary feeding at the right

age, reducing the likelihood of children becoming malnourished. (Ndolo M, 2006). Higher rates of illness among children in this age group also increase the chance of wasting among children. (Mukiraet *al*., 2005). Like in the other two nutritional indices cited above, sex differences in wasting showed that a higher proportion of males (6.9 percent) than females (5.5 percent) were wasted. This pattern of malnutrition identifies male children to be at higher risk of malnutrition.

4.2.3. Levels of Underweight

The prevalence of underweight is defined as the percentage of children whose weights are ≤ -2 below the median weight for age groups using the WHO international growth reference standards. Underweight is a reflection of chronic and acute malnutrition. The mean Z score for underweight in the study was 0.66, lower than -0.9 that was reported in KDHS 2008 - 2009, the prevalence of severe underweight which is defined as ≤ 3 was found to be 1.91 percent, which is much lower than the 4.2 percent that was observed three years prior to this survey in KDHS. It was higher in the rural (2.3 percent) than in the urban (1.0 percent) children.

The prevalence of underweight among pre-school children in this study was 12.7 percent and varied, marginally, by residence between rural and urban dwellers (13.2 percent and 11.4 percent respectively). Unlike stunting, this difference in rural-urban prevalence of underweight was not statistically different. Underweight on the other hand was more prevalent among the 12-23 months old. Sex differences in underweight showed that a higher proportion of males (15.1 percent) than females (9.9 percent) were identified as being underweight.

4.2.4. Social Economic Status and Nutritional Status of Children

One of the strong determinants of nutritional status in children is the economic status of the child's household (Smith et al., 2005). Studies have shown that Social Economic Status (SES) is significantly related to child stunting, linear growth retardation or low height-for-age (Abuya, Ciera, & Kimani-Murage, 2012). Stunting is a useful anthropometric measure for children in terms of its positive correlation with social and economic deprivation. Stunting and underweight rates were higher in the children in the lowest wealth quintile; see Table 4-1, which indicates the distribution of nutritional status by wealth quintiles. Children in the middle wealth quintiles are generally more stunted, wasted and underweight than those in the highest wealth quintile. Wasting and underweight on the other hand was lowest (3.1 percent) in the highest wealth quintile. In households with high levels of poverty, the individuals often have low access to food, inadequate resources for care in addition to not being able to utilize resources for health sustainably (Smith et al., 2005). Just as reported in the nutritional situation analysis of children 2009, the nutritional gap between children from poorest and wealthiest households remains high (UNICEF, 2010).

4.3. Nutritional status in adults

Nutritional status in the non-pregnant women and men was defined by Body Mass Index (BMI), which is calculated as weight (kg) divided by height squared (m^2). It is a simple measurement of body weight in relation to height. According to Garenne (2011), the height of adult women is considered stable after age 20 years. Height is an important anthropometric indicator because it defines stature. In the KNMS study, any respondents whose information on height and or weight was unavailable have been excluded from this analysis.

4.3.1. Levels of Malnutrition in Non-pregnant Women

The average height of adult women in this study was 159.5 ± 7.6 cm, average weight was 58.2 ± 14.1kg, and average BMI was 23.8 ± 5.4 kg/m^2. Mean BMI was higher in the urban non-pregnant women (24.1 ± 5.8kg/m^2) than rural (21.9 ± 4.9kg/m^2). Table 4.2 illustrates the prevalence's of nutritional status of the non-pregnant women assessed during this survey. Among the non-pregnant women of reproductive age, the overall prevalence of thinness was 13.2 percent, comparable with what was reported by KDHS 2008 - 2009, of 12 percent.

There was considerable variability in prevalence of thinness between rural and urban non-pregnant women dwellers where rural women showed much higher (16.1 percent) prevalence than those in the urban (9.1 percent). This pattern is similar to that reported in KDHS 2008 - 2009, in which consistently thinness is higher in the rural than urban women. It is well documented that being underweight is normally the result of deficit energy consumption while being overweight is related to excess energy intake (Khan & Kraemer, 2009). According to Finucane et al (2011) by 2008, the lowest mean female BMIs in sub saharan Africa had reached around 21 kg/m2, suggesting that underweight prevalence has decreased, but that underweight might still affect some populations as evidenced in this survey where a considerable 16.1 percent of women are still thin.

With respect to being overweight and or obese, the overall prevalence among non-pregnant women was 23.9 percent. This prevalence differed significantly between rural (16.1 percent) and urban (35.1 percent) non-pregnant women.

There is also a considerable association between overweight and social economic status (represented here by wealth quintiles), level of education and an increase in age. This study found a direct association between the level of wealth quintile and nutritional status in non-pregnant women. The highest prevalence of overweight/obesity (44.0 percent) was found in women in the highest level of wealth quintile while the highest prevalence of thin women was found in those in the lowest wealth quintile. This difference was statistically different and the distribution is further illustrated in Table 4-2. Our findings concur with findings from other studies where women of higher socio-economic status are more likely to be overweight or obese than their poorer counterparts (Zirabaet al.,2009; Ali & Crowther, 2009; Garenne, 2011). This is further supported by (Blanchard, 2009) where it is noted that as income increase, obesity increases. This may be the case in these studies including the current survey, however, there is seemingly a changing trend in presentation of overweight and obesity, where the

Table 4. 2: Factors associated with nutritional status in non-pregnant women

		n	Thinness (%) (BMI<18.5)	Normal (%) (BMI 18.5 – 25.0	Overweight (%) (BMI >25-30	Obese (%) (BMI >30)
Residence	Rural	410	16.1	67.8	11.2	4.9
	Urban	285	9.1	55.8	23.5	11.6
Level of Education	Preschool	71	39.4	57.7	2.8	0.0
	Primary	365	12.1	64.1	16.2	7.7
	Secondary, A level	236	7.6	61.4	21.2	9.7
Wealth index quintiles	Poorest	133	27.1	66.2	4.5	2.3
	Second	147	13.6	76.9	5.4	4.1
	Middle	128	11.7	64.8	21.10	2.3
	Fourth	155	9.7	54.8	24.50	11.0
	Richest	132	4.5	51.5	25.80	18.2

Table 4. 3: Status of Non-pregnant Women (NPRG) and Men using BMI

Age Group	Residence	n	Total Thinness (BMI<18.5) Weighted (%)	Normal (BMI=18.5-<25) Weighted (%)	Overweight & Obese (BMI>25) Weighted (%)
NPRG	Rural	410	16.1	67.8	16.1
	Urban	285	9.1	55.8	35.1
	Total	**695**	**13.2**	**62.9**	**23.9**
Men	Rural	184	30.4	60.3	9.2
	Urban	95	13.7	69.5	16.8
	Total	**279**	**24.7**	**63.4**	**11.8**

shift is showing that, equally, populations from poor social economic status are also presenting very high prevalence of overweight and obesity. Monteiro et al, 2004 reviewed data from several studies in developing countries and found that obesity in the developing world can no longer be considered solely a disease of groups of higher SES.

In regard to education levels, overweight and obesity prevalence was higher (30.9 percent) in those with secondary or above levels of education (overweight 21.2 percent and obese 9.7 percent) followed by those with primary education who showed a prevalence of 23.9 percent, (overweight 16.2 percent and obese (7.7 percent) while thinness was prevalence in those who only attained preschool education at 39.4 percent. A statistically significant difference was observed between the various levels of education. The higher the education level, the higher the prevalence of overweight and obesity. These findings are similar in many populations where the level of education is directly related with obesity especially in women (Ali & Crowther, 2009). KDHS 2008 - 2009 showed a similar pattern where women with higher education presented the highest prevalence of overweight and obesity though for overweight, women without education had apparently higher prevalence than those with primary education (KNBS AND ICF Macro, 2010, 2009). Education appears to be protective for the underweight women but as a risk factor for the overweight and obese women (Khan & Kraemer, 2009).

4.3.2. Levels of Malnutrition in Men

The KNMS survey is among a few such studies that considered the inclusion and assessment of nutritional status of men and BMI was used for the classification of nutritional status. Unlike in the female population, the discussions regarding nutritional status in men is mainly based on the mean BMIs. The average height, weight and BMI of the adult men in this study was 169.3 ± 7.6 cm, 60.7 ± 14.19kg/m^2, and 21.1 ± 4.4 kg/m^2 respectively. The mean BMI was higher in the men residing in urban areas (22.2 ±4.9 9kg/m^2) compared to the rural male population (20.5 ±3.9kg/m^2). Wasting among men was observed to have an overall prevalence of 24.7 percent. Rural men were more than twice (30.4 percent) the prevalence of wasting in urban men (13.7 percent).

The overall prevalence of overweight (including obesity) among men was 11.8 percent. Males in rural areas had much lower prevalence (9.2 percent) than urban male dwellers (16.8 percent). This pattern of rural and urban distribution followed the same pattern with that seen in women. It is believed that populations in the urban settings are highly predisposed to sedentary lifestyles including intake of highly refined diets, which are some of the known factors associated with increase in BMI.

Table 4. 4: Factors associated with nutritional status in men

		n	Thinness (BMI <18.5)	Normal (BMI 18.5 - <25)	Overweight & Obese (BMI >25)
Residence	Rural	184	30.4	60.3	9.2
	Urban	95	13.7	69.5	16.8
Education level	None	17	64.7	29.4	5.9
	Primary	141	31.2	62.4	6.4
	Secondary & above	120	11.7	70.0	18.3
Wealth index quintiles	Lowest	54	55.6	40.7	3.7
	Second	68	19.1	72.1	8.8
	Middle	56	14.3	69.6	16.1
	Fourth	54	29.6	63.0	7.4
	Highest	47	4.3	70.2	25.5
Total		**279**	**24.7**	**63.4**	**11.8**

In regard to education, the lowest mean BMI was found in men without education at 18.6 ± 2.6 kg /m2 and highest in those with secondary and above levels of education (21.1 ± 4.4kg /m^2). Although the mean BMI was within the normal range, the poorest men had the lowest BMI (19.6 ± 5.1 kg /m^2) while those with highest SES had the highest mean BMI (23.9 ± 5.9 kg /m^2). The middle class had higher mean BMI (21.5 ±3.5 kg/ m2) when compared to the second and fourth quintiles where the mean was 20.3 ± 2.5 kg /m2 and 20.7 ± 3.4 kg /m^2 but lower than in the highest wealth quintile.

Nationally, the prevalence of thinness in men was higher than amongst women. This study has shown that more men in Kenya are likely to be underweight (thin) 24.7 percent when compared to women whose prevalence of underweight is 13.2 percent. The findings also show a consistency in the levels of education in both women and men, where those with the lowest education had the lowest mean BMI. The pattern of inverse relationship between SES and nutritional status in women is not observed the men. Explanations of the inverse association between SES and obesity among women, or the lack of association among men shown to exist in lower-middle-income and upper-middle income developing economies are complex and more research is necessary (Monteiro et al., 2004).

4.3.3. Nutrition Status of Pregnant Women by Mid Upper Arm Circumference

Mid Upper Arm Circumference (MUAC) does not vary much during pregnancy and is therefore an appropriate measure of nutritional status than BMI or weight (Assefa *et al.*, 2012). In MUAC measurements, pregnant women with measurements of <23.0 cm are considered to be thin.

Table 4. 5: Nutrition status of pregnant women by Mid Upper Arm Circumference

	n	Total Thinness (MUAC<23cm) Weighted (%)	Normal (MUAC>23cm) Weighted (%)
Rural	71	11.4	88.6
Urban	46	12.0	88.0
Total	**117**	**11.7**	**88.3**

The results of this study show that, overall, the prevalence of thinness among pregnant women was 11.7 percent with little variability between rural (11.4 percent) and urban (12.0 percent) residents. The mean MUAC in the pregnant women was 26.4 SD 4.0 cm.

CHAPTER FIVE: ANAEMIA, IRON DEFICIENCY, IRON DEFICIENCY ANAEMIA AND ASSOCIATED FACTORS

5.1. Introduction

Anaemia is a public health problem associated with, among others, impaired cognitive and motor development in children and increases the risk of mortality for the mothers and neonates. It is a condition in which the number of red blood cells (and consequently their oxygen-carrying capacity is insufficient to meet the body's physiological needs. Specific physiological needs vary with a person's age, gender, altitude, smoking behaviour, and different stages of pregnancy. Although the primary cause of anaemia is iron deficiency, it is seldom present in isolation. More frequently, it coexists with a number of other causes such as malaria, parasitic infection, nutritional deficiencies (including folate, vitamin B_{12} and vitamin A), and inherited or acquired disorders that affect haemoglobin synthesis, red blood cell production or red blood cell survival (WHO, 2008; KMIS, 2010; WHO, 2011).

Haemoglobin concentration is widely used to diagnose anaemia while the concentration of plasma (or serum) ferritin is positively correlated with the size of the total body iron stores in the absence of inflammation. A low serum ferritin value reflects depleted iron stores, but not necessarily the severity of the depletion as it progresses (WHO, 2001). Table 5-1 below indicates the proposed classification of public health significance of anaemia in population on basis of prevalence estimated from blood levels of haemoglobin.

Table 5. 1 Proposed classification of public health significance of anaemia in populations

Category of public health significance	Prevalence of anaemia (%)
Severe	> or = 40
Moderate	20.0 – 39.9
Mild	5.0 – 19.9
Normal	< or = 4.9

A summary of the prevalence of anaemia, iron deficiency and iron deficiency anaemia in all the age categories evaluated during the survey period is as indicated in the Table 5-2 below.

Table 5. 2: Prevalence of Anaemia, Iron deficiency (ID) and Iron deficiency anaemia (IDA) in the study population

Study group	Anaemia				Iron Deficiency				Iron Deficiency Anaemia			
	N	weighted (%) anaemia	95% C.I. Lower	Upper	n	weighted (%) ID	95% C.I. Lower	Upper	n	weighted (%) IDA	95% C.I. Lower	Upper
PSC	827	26.3	23.30	29.30	918	21.8	19.13	24.47	827	13.3	10.99	15.61
SAC	872	16.5	14.04	18.96	942	9.4	7.54	11.26	942	4.9	3.52	6.28
PW	104	41.6	32.13	51.07	111	36.1	27.16	45.04	104	26.0	17.57	34.43
NPW	592	21.9	18.57	25.23	633	21.3	18.11	24.49	592	14.0	11.20	16.80
Men	240	9.3	5.87	13.33	247	3.6	1.28	5.92	243	2.9	0.79	5.01
Total	**2635**	**23.1**	**21.5**	**24.7**	**2851**	**18.4**	**17.0**	**20.0**	**2708**	**12.2**	**11.0**	**13.4**

In the study population, the highest prevalence of anaemia, iron deficiency and iron deficiency anaemia was noted in pregnant women (41.6 percent, 36.1 percent and 26 percent respectively), and lowest prevalence of anaemia, iron deficiency and iron deficiency anaemia noted in men (9.3 percent, 3.6 percent and 2.9 percent respectively). Overall, the prevalence of anaemia in Kenya was 23.1 percent compared to the global and Africa prevalence of 24.8 percent and 40.7 percent respectively (WHO, 2008).

5.2. Anaemia, Iron Deficiency and Iron Deficiency Anaemia in Pre-School Aged Children (6-59 months)

Full-term infants are normally born with adequate iron stores in the liver and haematopoietic tissue, because of destruction of fetal red blood cells soon after birth. Breast milk is relatively low in iron,

Table 5. 3: Anaemia, iron deficiency (ID), and iron deficiency anaemia (IDA) among pre-school age children (6-59 months) in relation to selected demographic and economic characteristics

Characteristic	N	Anaemia, weighted %	n	ID, weighted %	n	IDA, weighted %
Age in months						
6-11	65	41.5	79	26.6	65	24.6
12-23	123	42.3	133	34.6	122	20.5
24-35	201	24.4	219	21.0	201	8.5
36-47	229	21.8	248	19.4	228	11.0
48-59	210	19.0	236	16.5	209	9.1
Sex						
Male	455	27.7	503	23.3	456	13.8
Female	372	24.7	415	20.0	372	11.0
Residence						
Rural	592	26.9	662	21.5	592	12.5
Urban	234	24.8	255	22.7	234	12.4
Level of education of the household head						
Preschool/ None	150	34.7	162	34.0	149	20.1
Primary	405	29.4	446	21.3	405	13.8
Post primary/ Vocational	191	17.3	220	12.3	192	6.3
College/ University	77	16.9	85	27.1	78	7.7
Not stated	4	25.0	5	0.0	4	0.0
Wealth Quintile						
Lowest	240	31.7	262	22.9	240	13.8
Second	214	27.6	241	20.3	214	14.5
Middle	129	31.0	151	25.2	129	15.5
Fourth	119	14.3	136	18.4	119	5.9
Highest	124	20.2	128	21.9	124	9.7
TOTAL	**827**	**26.3**	**918**	**21.8**	**827**	**12.5**

although the iron in breast milk is much better absorbed than that in cows' milk. Iron deficiency commonly develops after six months of age if complementary foods do not provide sufficient absorbable iron, even for exclusively breastfed infants. Iron requirements on a body weight basis are proportional to growth velocity (WHO 2007).

In the KNMS 2011, haemoglobin cut-offs of less than 11g/dL were used to diagnose anaemia in children aged 6-59 months. Ferritin cut-off of less than 12µg/L was used in diagnosing iron deficiency (ID), while the combination of haemoglobin and ferritin cut-off values was used to compute iron deficiency anaemia (IDA).

5.2.1. Anaemia in children aged 6-59 months

The overall (National) prevalence of anaemia among pre-school children was 26.3 percent compared to the global prevalence of 47.4 percent. In Africa, the estimated prevalence of anaemia in preschool children is 67.6 percent (WHO, 2008). There was no variability in prevalence of anaemia between residences (rural 26.9% versus urban 24.8%). In terms of distribution of anaemia by sex, male children had a higher prevalence of anaemia than females (27.7 percent and 24.7 percent respectively) though the difference was not significant. When the prevalence of anaemia was considered by age sub-categories, significant variation was noted between the younger children (6-11 months 41.5 percent and 12-23 months 42.3 percent) and the older children (24-35 months 24.4 percent, 36-47 months 21.8 percent and 48-59 months 19.0 percent) with a consistent reduction in prevalence of anaemia as the age increased (Table 5-3 above). The Kenya Malaria Indicator Survey (KMIS) 2010 also observed similar patterns where the proportion of anaemic children generally declined with age from 62.7 percent in children 6-8 months to 38 percent in children 36-39 months, and the proportions varied little with residence (urban 23.6 percent & rural 26.5 percent) and gender (male 26.9 percent & female 25.2 percent).

Socio-economic status presented as wealth quintiles is considered an important factor in anaemia prevalence, and ranges from the lowest to the highest. In this study, wealth quintile was found to be a significant factor in anaemia. The lowest wealth quintiles showed much higher prevalence of anaemia (31.7 percent) compared to those in the higher wealth quintiles (14.3 percent in fourth and 20.2 percent in highest wealth quintile). The KNMS 2011 showed similar prevalence of anaemia in the lowest and second wealth quintiles to those reported by KMIS 2010 (lowest 31.5 percent & second 28.3 percent). It is important when making such comparisons to bear in mind variations in anaemia caused by differences in assessment methodology and source of blood sample i.e. capillary versus venous. Some studies suggest that haemoglobin values measured in capillary samples are higher than those measured in venous samples, potentially leading to false-negative results (WHO, 2011). In KNMS, venous blood was used. The HemoCue® system used in both KNMS and KMIS was based on the cyanmethemoglobin method that has been shown to be stable and durable in field settings. In the 1999 survey HemoCueTM, Angelholm, Sweden was used to test for Hb.

There was a notable decline in the national prevalence of anaemia in preschool children from 69 percent in 1999 national micronutrient survey to 46.1 percent in 2010 national malaria indicator survey and then to 26.3 percent in 2011 national micronutrient survey. A decline in anaemia prevalence in preschool children may be attributed to the many interventions put in place after the 1999 survey. These include micronutrient deficiency prevention and control programmes, such as promotion of intake of iron rich foods, prevention and control of helminths, and prevention, control and prompt treatment of malaria in children. The decline in anaemia prevalence between 2010 and 2011 may be attributed to low malaria prevalence during the time of conducting KNMS 2011 survey. According to the KMIS 2010 report, twenty percent of the anaemia cases could have been attributed to malaria. For this reason, anaemia

in children under five years is likely to be higher if assessments are done during peak malaria transmission seasons. Currently therefore and in accordance with World Health Organisation classification, prevalence of anaemia in preschool children in Kenya is moderate (Table 5-1).

5.2.2. Iron Deficiency in children aged 6-59 months

The overall (National) prevalence of Iron Deficiency in the Pre-school age children was 21.8 percent. There was a significant difference in iron deficiency prevalence among the age sub-categories. The prevalence was highest in 12-23 months age sub-categories (34.6 percent) and lowest in the oldest (48-59 months) with a prevalence of 16.5 percent. Infants 6-11 months had a prevalence of 26.6 percent.

Similar to the trends observed with anaemia, the prevalence of iron deficiency did not differ between the sexes or residence (rural versus urban). However, while differences in the anaemia prevalence were observed by wealth quintiles, there was no statistical difference in iron deficiency by wealth quintile.

Physiologically, normal ferritin concentrations vary by age and sex. Concentrations are high at birth, rise during the first two months of life, and then fall throughout later infancy. At about one year of age, concentrations begin to rise again and continue to increase into adulthood (WHO, 2011). What was notable in KNMS 2011 was that it is the 12-23 months age group that recorded the highest (34.6 percent) iron deficiency, which tapers off after two years. This brings into question the management and care practices in this cohort of children. Poor complementary foods that are low in bio-available iron are some of the major contributors to iron deficiency and anaemia in this age group.

The KNMS 2011 recorded a general decline in iron deficiency prevalence compared to the 1999 survey that reported prevalence of marginal to severe iron deficiency of 35.2 percent, 38 percent, 29.1 percent, 32 percent and 46 percent among 6-11, 12-23, 24-35, 36-47 and >47 months old children respectively. This again can be attributed to the success of micronutrient deficiency prevention and control programmes, that include use of food based approaches to prevention of iron deficiency in children, an example being promotion of intake of iron rich foods such as animal products.

5.2.3. Iron Deficiency Anaemia (IDA) in children aged 6-59 months

With respect to iron deficiency anaemia, the overall (national) prevalence was 13.3 percent. There was a notable difference in prevalence of iron deficiency anaemia between the younger children (6-23 months) and the older children (24 – 59 months) of the pre-school age. The trend in the distribution of IDA by wealth quintiles was noted to be lowest (5.9 percent) among those in the fourth wealth quintiles and highest (15.5 percent) in the middle wealth quintiles though the difference in prevalence of iron deficiency anaemia within the wealth quintiles was not statistically significant. Despite the male children and the rural population recording higher IDA, the prevalence did not differ significantly between sexes and residence (rural versus urban).

5.3. Anaemia, Iron Deficiency and Iron Deficiency Anaemia in School Age Children (5-14 years)

In the KNMS 2011, haemoglobin cut-offs of less than 11.5 g/dL for 5-11 years and less than 12 g/dL for 12-14 years were used to diagnose anaemia. Ferritin cut-offs of less than 15.0g/dL were used in diagnosing iron deficiency (ID), while the combination of haemoglobin and ferritin cut-off values was used to compute iron deficiency anaemia (IDA).

Table 5. 4: Anaemia, iron deficiency (ID), and iron deficiency anaemia (IDA) among School Age Children (5– 14 years) in relation to selected demographic and economic characteristics

Characteristic	n	Anaemia %	n	ID (%)	n	IDA (%)
Gender						
Male	419	17.9	444	10.1	402	4.5
Female	453	15.0	499	8.8	450	5.3
Residence						
Rural	643	18.5	694	9.9	618	5.3
Urban	230	10.9	248	7.7	233	3.9
Education of household head						
None or Pre School	164	29.3	160	19.4	145	11.0
Primary	444	15.1	485	7.8	441	4.1
Secondary	216	11.6	246	7.7	216	3.7
Tertiary/college/university	40	7.5	42	0.0	42	0.0
Wealth Quintile						
Lowest	233	26.2	249	14.9	226	9.7
Second	224	9.8	258	9.3	226	1.8
Middle	188	19.7	203	4.9	175	4.0
Fourth	139	9.4	137	8.0	134	4.5
Highest	88	12.5	93	5.4	91	3.3
Total	**872**	**16.5**	**942**	**9.4**	**942**	**4.9**

5.3.1. Anaemia in School age children

The median age for school age children with anaemia was 8 years compared to 9 years without anaemia. Overall prevalence of anaemia among school age children was 16.5 percent which is lower compared to the global prevalence of 25.4percent (WHO 2008). The prevalence varied between gender; males had a higher prevalence (17.9 percent) compared to females (15 percent), though the difference was not significant. Similar to PSC, the prevalence of anaemia was noted to be significantly higher (18.5 percent) among school age children in rural areas compared to those in urban areas (10.9 percent) (Table 5-4 above).

Educational levels of household heads were observed to relate with the prevalence of anaemia in school age children in that those household heads who had never attended school had children with much higher (29.3 percent) prevalence of anaemia than those with primary school education and above. Analysis of anaemia in the school age children by wealth quintiles showed that children in the lower wealth quintiles had, highest prevalence of anaemia (26.2 percent) followed by middle (19.7 percent) and highest (12.5 percent) while those in the fourth and second wealth quintiles had the lowest (9.4 and 9.8 percent respectively).

5.3.2. Iron Deficiency in school age children

School age children that were found to be iron deficient, (as is the case of those with anaemia), had a median age of 8 years, while those who were non deficient had a median age of nine years. The overall prevalence of iron deficiency was 9.4 percent compared to the global prevalence of 46 percent (WHO, 2011). Although the prevalence of iron deficiency showed marginal differences between gender (10.1 percent in males and 8.8 percent in females) the difference were not statistically significant. As was the case with anaemia, when the distribution of prevalence of iron deficiency was considered against levels of education,

children whose household head had no education had the highest (34.7 percent) prevalence of iron deficiency compared to those with primary level of education and above. Variability in prevalence of iron deficiency anaemia was also observed between wealth quintiles where children in the lowest wealth quintiles had, the highest (14.9 percent) prevalence of iron deficiency while those in the middle wealth quintiles showed the lowest prevalence (4.9 percent). It is important therefore for efforts geared towards tackling iron deficiency to bear in mind the social and environmental determinants of IDA in the population.

5.3.3. Iron Deficiency Anaemia in school age children

Iron deficiency anaemia among school age children had an overall prevalence of 4.9 percent with the median age in those children with anaemia of 7 years compared with the median age of those without iron deficiency anaemia of 9 years. The prevalence of iron deficiency anaemia showed no significant difference between males and females. Higher prevalence (5.3 percent), albeit not significant, was also seen among rural dwellers than among urban residents (3.9 percent). Education level of household head was an important determinant of prevalence of iron deficiency anaemia among school age children. There was a significant difference in the prevalence of iron deficiency anaemia in children according to the education level of household heads. Children whose household head had no education had prevalence of iron deficiency anaemia of 11.0 percent and those whose household head had primary school education and secondary level education had prevalence of 4.1 percent and 3.7 percent respectively, where in households whose household head had tertiary level of education, there were no reported cases of IDA. Further, significant variability in prevalence of iron deficiency anaemia was seen among the children in their different wealth quintiles. Children in the lowest wealth quintiles had the highest prevalence of 9.7 percent while children in the second wealth quintile had the lowest prevalence (1.8 percent). The distribution of the prevalence across other wealth quintiles was relatively equal (3.3-4.5 percent). There was a significant difference in distribution of iron deficiency according to the wealth quintiles.

5.4. Anaemia, Iron Deficiency and Iron Deficiency Anaemia in Non-Pregnant Women (15-49 years)

In the KNMS 2011, haemoglobin cut-offs of less than 12g/dL were used to diagnose anaemia in non-pregnant women. Ferritin cut-offs of less than 15µg/L was used in diagnosing iron deficiency (ID), while the combination of haemoglobin and ferritin cut-off values was used to compute iron deficiency anaemia (IDA).

Table 5. 5: Anaemia, iron deficiency (ID), and iron deficiency anaemia (IDA) among School Age Children (5– 14 years) in relation to selected demographic and economic characteristics

Characteristic	n	Anaemia, weighted %	n	ID, weighted %	n	IDA, weighted %
Age in years						
15 – 19	116	13.8	122	15.6	119	7.6
20 – 49	475	23.8	511	22.7	473	15.6
Residence						
Rural	370	24.6	397	21.4	363	13.2
Urban	221	17.2	236	21.2	229	15.3
Level of Education						
Preschool/None	68	41.2	69	39.1	60	33.3
Primary	309	21.0	344	18.6	321	11.2
Post primary/ Vocational	175	20.6	179	23.5	174	14.9
College/ University	40	2.5	41	4.9	36	2.8
Wealth Quintile						
Lowest	107	34.6	120	27.5	101	20.8
Second	112	22.3	130	20.0	129	13.2
Middle	119	22.7	123	26.0	118	12.7
Fourth	110	19.1	111	18.9	130	10.8
Highest	145	13.8	148	15.5	114	14.0
TOTAL	**592**	**21.9**	**633**	**21.3**	**592**	**14.0**

5.4.1. Anaemia in non-pregnant women

Non-pregnant women had an overall prevalence of anaemia of 21.9 percent (Table 5-5 above) which is lower compared to global prevalence of 30.2 percent, the African prevalence of 47.5 percent (WHO 2008), and that reported in 1999 national micronutrient survey of 47.9 percent. Prevalence of anaemia varied significantly between rural and urban residences of the non-pregnant women with those in rural areas registering a higher prevalence (24.6 percent) than the urban residents (17.2 percent). It is worth noting that about a third of anaemia cases among older individuals are said to be caused by iron, folate, or B_{12} deficiency (Fomovska et al., 2008).

Upon examining the relation between prevalence of anaemia and educational levels, notable significant differences were observed between those with no education (41.2 percent) and those with college/university level of education (2.5 percent). This scenario was also seen with levels of wealth quintiles, where those women in the lowest wealth quintiles had significantly much higher prevalence of anaemia than those in the higher wealth quintiles (13.8 percent). Previous studies have observed similar patterns where education, region of residence and wealth status are some of the factors associated with occurrence anaemia in Africa (Ngnie-Teta et al., 2008).

5.4.2. Iron Deficiency in non-pregnant women

The overall (National) prevalence of iron deficiency among non-pregnant women was 21.3 percent compared to 47.5 percent in 1999 national micronutrient survey. Prevalence of iron deficiency did not differ between women in rural (21.4 percent) and those of urban residence (21.2 percent) possibly because physiologically, serum ferritin values among women remain relatively low until menopause and then rise (WHO, 2011). However, significant differences

existed with levels of education attained by these women, where those with no education had high prevalence (39.1 percent) compared to those with college/university education (4.9 percent).

Analysis by wealth quintiles showed that non-pregnant women in the lowest wealth quintile had a higher (27.5 percent) prevalence of iron deficiency than those in the highest wealth quintile (15.5 percent), although this difference was not statistically significant. The current findings highlight the importance of a multi-sectoral holistic approach in addressing anaemia problems. There is need to empower women through engagement and education (Tengco et al., 2008).

5.4.3. Iron Deficiency Anaemia in non-pregnant women

Iron deficiency anaemia had an overall (National) prevalence of 14.0 percent. Prevalence varied between women residing in the rural and urban areas with those in urban showing higher (15.3 percent) prevalence compared to those in rural (13.2 percent) although these differences were not statistically significant. Educational levels were noted to be significant determinants in the prevalence of iron deficiency, with those women without education showing a high (33.3 percent) prevalence of iron deficiency anaemia compared to those with college/university levels of education (2.8 percent). The trend of differences in prevalence of iron deficiency anaemia is also reflected in the different wealth quintiles where the lowest wealth quintile had the highest prevalence (20.8 percent) while the fourth highest wealth quintile had the lowest prevalence (10.8 percent). These differences however were not statistically significant.

5.5. Anaemia, Iron Deficiency and Iron Deficiency Anaemia in Pregnant Women (15-49 years)

In the KNMS 2011, haemoglobin cut-offs of less than 11.0 g/dL were used to diagnose anaemia in pregnant women. Ferritin cut-offs of less than 15.0µg/L was used in diagnosing iron deficiency (ID), while the combination of haemoglobin and ferritin cut-off values was used to compute iron deficiency anaemia (IDA).

Table 5. 6: Anaemia, iron deficiency, and iron deficiency anaemia among pregnant women (15–49 years) in relation to selected demographic and economic characteristics

Characteristic	n	Anaemia, weighted %	n	ID, weighted %	n	IDA, weighted %
Age in years						
15 – 19	17	41.2	19	31.6	18	27.8
20 – 49	86	41.9	92	37.0	86	25.6
Residence						
Rural	61	50.8	68	45.6	60	36.7
Urban	44	29.5	43	20.9	44	11.4
Level of Education						
Preschool/None	23	65.2	22	54.5	22	45.5
Primary	59	33.9	65	32.3	59	16.9
Post primary/ Vocational	16	56.3	15	40.0	15	40.0
College/ University	7	0.0	8	0.0	7	0.0
Wealth Quintile						
Lowest	23	56.5	26	42.3	23	34.8
Second	28	53.6	30	46.7	28	39.3
Middle	17	35.3	20	45.0	17	23.5
Fourth	16	18.8	17	17.6	16	12.5
Highest	20	35.0	20	20.0	20	5.0
TOTAL	**104**	**41.6**	**111**	**36.1**	**104**	**26.0**

5.5.1. Anaemia in pregnant women

Haemoglobin concentrations change dramatically during pregnancy to accommodate the increasing maternal blood volume and the iron needs of the foetus (WHO, 2011). Maternal anaemia is associated with a higher risk for low birth weight, premature birth, perinatal and neonatal death, as well as inadequate iron stores for the newborn.

The overall prevalence of anaemia (National) in pregnant women was 41.6 percent (Table 5-6) compared with global and African prevalence of 41.8 percent and 57.1 percent respectively. This was a decrease from 55.1 percent reported in 1999 national micronutrient survey. These prevalence were noted to be significantly higher in rural (50.8 percent) than urban areas (29.5 percent). Further, within the wealth quintile categories, prevalence of anaemia were highest in those in the lowest wealth quintile (56.5 percent) and lowest among women in the fourth wealth quintile (18.8), although this difference is not statistically significant.

In relation to levels of education, anaemia was highest (56.2 percent) among those that never attended school. Those with post primary/ vocational level of education also registered higher prevalence of anaemia (56.3 percent) than those with primary level of education (33.9 percent). There were no cases of anaemia in those with college/university level of education. This again highlights the need for a holistic approach in addressing the social determinants of health ranging from interlocution between the society's socioeconomic, cultural, and environmental policies to the creation of educational programs to change personal habits (Cotta et al., 2011).

5.5.2. Iron Deficiency in pregnant women

Overall (National) prevalence of iron deficiency among pregnant women was 36.1 percent. However, in interpreting these results, it is important to note that serum ferritin is of limited use in diagnosing iron deficiency during pregnancy, as concentrations fall during late pregnancy, even when bone marrow iron is present (WHO, 2011).

Prevalence of iron deficiency differed significantly in distribution between rural (45.6 percent) and urban residents (20.9 percent). Similarly, significant variability in prevalence of iron deficiency was registered in the different levels of education. Among women who had no education, the prevalence was highest (54.5 percent) and lowest (32.3 percent) in those who had primary education. There were no cases of iron deficiency in those with college/ university level of education. There were differences in prevalence of iron deficiency according to wealth quintiles with the highest prevalence noted in second wealth quintile (46.7 percent) and the lowest prevalence noted in the fourth wealth quintiles (17.6 percent). However, this difference was not statistically significant.

5.5.3. Iron Deficiency Anaemia in pregnant women

The overall (National) prevalence of iron deficiency anaemia was 26.0 percent and like iron deficiency, there was a significant variability between rural and urban women dwellers. Among rural women, the prevalence was high (36.7 percent) compared to that of urban women (11.4 percent). High prevalence of iron deficiency anaemia was seen in women who had never attended school (45.5 percent) and those with secondary school and vocational training (40.0 percent) (Table 5-6). Those with primary level of education registered a low prevalence of IDA (16.9 percent). There were no cases of IDA in pregnant women with college/university education. There was a significant difference in distribution of IDA across the wealth quintiles. Women who belonged to the second lowest wealth quintiles had high prevalence (39.3 percent) compared to those in the highest wealth quintiles (5.0 percent). There was a significantly different distribution of IDA across the wealth quintiles.

5.6. Anaemia, Iron Deficiency and Iron Deficiency Anaemia in Men (15-54 years)

In the KNMS 2011, haemoglobin cut-offs of less than 13 g/dL were used to diagnose anaemia in men. Ferritin cut-offs of less than 15.0µg/L was used in diagnosing iron deficiency (ID), while the combination of haemoglobin and ferritin cut-off values was used to compute iron deficiency anaemia (IDA).

Table 5. 7: Anaemia, iron deficiency, and iron deficiency anaemia among men (15– 54 years) in relation to selected demographic and economic characteristics

Characteristic	n	Anaemia%	N	ID%	N	IDA%
Residence						
Rural	144	11.8	148	4.7	144	3.5
Urban	96	5.2	99	2.0	98	2.0
Level of education						
None/pre school	9	0.0	9	22.2	8	0
Primary	114	9.6	117	3.4	113	2.7
Secondary/post primary/vocational	103	9.7	107	3.7	106	3.8
Tertiary and above	15	13.3	15	0	15	0
Wealth Quintile						
Lowest	38	15.8	39	5.1	39	5.1
Second	65	12.3	67	7.5	64	4.7
Middle	36	8.3	37	0	37	0
Fourth	56	7.1	58	3.4	56	3.6
Highest	45	2.2	47	0	47	0
Total	**240**	**9.2**	**247**	**3.6**	**243**	**2.9**

5.6.1. Anaemia in men

The overall (National) prevalence of anaemia among men was 9.3 percent (Table 5-7 above) compared to global prevalence of 12.7 percent (WHO 2008). This is a reduction from the 1999 national survey that had also noted a significant lower burden of anaemia (20 percent) in older children, adult men and the elderly (Mwaniki et al., 1999). Higher prevalence was observed in rural males than their urban counterparts (11.8 percent and 5.2 percent respectively) though not significantly different.

With respect to the levels of education, no anaemia cases were reported in men with no education. Highest prevalence (13.3 percent) of anaemia was reported in men with tertiary/ university level of education. Those with primary and secondary level of education had relatively equal prevalence of anaemia (9.6 percent and 9.7 percent respectively). These differences, however, were not statistically significant. Prevalence also differed among the male in different wealth quintiles such that the men in the lowest wealth quintile had the highest prevalence (15.8 percent) while those in the highest wealth quintile had the lowest prevalence (2.2 percent). Again these differences were not statistically significant.

5.6.2. Iron Deficiency in men

National prevalence of iron deficiency in men was 3.6 percent compared to prevalence of 4.9 percent reported in 1999 national micronutrient survey. The low prevalence can be attributed to physiological changes that accompany growth. Physiologically, beginning in adolescence, males have higher ferritin values than females, a trend that persists into late adulthood. Ferritin values among men peak between 30–39 years of age and then tend to remain constant until about 70 years of age (WHO, 2011). Although the distribution was variable between rural and urban male residents where the prevalence were higher among rural than urban (4.7 percent and 2.0 percent respectively), this was shown not to be statistically significant (Table 5-8).

The variability in prevalence was also observed in the various levels of education where those males

with the lowest levels of education had the highest (22.2 percent) prevalence of iron deficiency compared with men with high educational levels (3.4 percent) i.e. secondary and beyond. This difference however was statistically insignificant. This trend of variability in prevalence of iron deficiency was also replicated in the wealth quintiles where those men belonging to the second wealth quintiles had, the highest prevalence (7.5 percent) while those in the middle wealth quintiles had lowest prevalence (0.0 percent).

5.6.3. Iron Deficiency Anaemia in men

The National prevalence of Iron deficiency anaemia was 2.9 percent and was notably variable between residences where those in the rural had higher (3.5 percent) prevalence than those in urban (2.0 percent). Differences in prevalence did not differ significantly by level of education, while the differences observed by wealth quintile were inconsistent with random distribution.

5.7. Factors that contribute to anaemia

Several factors such as iron deficiency, infections and blood disorders are known to contribute to the overall prevalence of anaemia in the population. Parasitic infections such as intestinal helminths can cause anaemia through a combination of blood loss and poor absorption of micronutrients. *Taenia solium* (pork tapeworm) and *T. saginata* are the most common types of tapeworms found in the region. Other important tapeworms include the fish tapeworm (*Diphllobothrium latum*) that is associated with consumption of raw fresh water fish, and the dwarf tapeworm (*Hymenolepis nana*) that commonly occurs in children. Whereas, tapeworms are associated with little or no symptoms, the fish tapeworm is known to compete with the host for absorption of vitamin B_{12}, whose deficiency may result in pernicious anaemia.

Two species of hookworms are known to infect humans, *Anyclostoma duodenale* and *Necator americanus*, with the latter being the dominant species in the sub Saharan Africa region. Hookworms feed on the blood off the wall of the small intestines, with moderate and heavy hookworm infection giving rise to intestinal inflammation and progressive iron/protein-deficiency anaemia (Smith and Brooker, 2010). On the other hand, *Schistosoma mansoni* eggs, which are highly immunogenic, lead to the development of anaemia of inflammation due to the sustained immune response of the host (Butler et al., 2012).

In this survey, stool samples were collected from Pre-School Children, School Age Children, Pregnant Women and Non-pregnant Women participants and examined for the presence of tapeworms, hookworms and S. mansoni. Besides helminths, other parasitic infections with widespread prevalence such as malaria can also contribute greatly to anaemia development in the host. In this case, malarial anaemia is due to clearance of uninfected cells by the spleen and poor generation of new red blood cells (Kai and Roberts, 2008).

Hereditary blood disorders, also known as heamoglobinopathies, constitute an important cause of anaemia due to their intrinsic nature. Sickle cell (SS) and thalassaemias are the two key heamoglobinopathies of importance in the region. Sickle Cell anaemia is a hereditary disorder of the blood characterized by mutation in the beta globin gene located on chromosome 11 and affects up to 3% of births in some parts of the continent and up to 85% of the global population with sickle cell disease is in Africa. The survival rate of children with SS is known to decrease with age (Barclay GP 1971), with high levels of early life mortality among children born with Sickle cell disease in this region (Grosse, S.D 2009, McAuley et al., 2010, Tshilolo L et al., 2008, Christianson AL, et al 2006). On the other hand, the thalassaemia is a group of genetic disorders characterised by reduced globulin units of haemoglobin as a result of underproduction of normal globin proteins (often through mutations in regulatory genes) that forms haemoglobin and do not cause fatalities (WHO 2008).

5.7.1. Infection of pre-school children with helminths

In this survey the overall prevalence for tape worm, hook worm and Schistosoma mansoni in the preschool age children (PSC) were 20.8, 22.5 and 21.4 percent respectively (Table 5.8). However, the distribution of disease burden by age, gender and residence was not different for any of the infections. Distribution of the parasitic infections based on a wealth quintiles was found to be statistically significant for tapeworm, hookworm and S. mansoni (p=0.001) with the highest infection rates occurring in the second followed by middle wealth index quartiles (Table 5-8). This is perhaps indicative of poverty-associated with poor sanitation that is not readily addressed by the public and not-for-profit sector in the former and lifestyle-associated behaviour in the latter.

Table 5. 8: Helminths among pre-school age children (6-59 months) in relation to selected demographic and economic characteristics

Characteristic	n	Tape worm, weighted %	n	Hook worm, weighted %	n	Schistosoma mansoni, weighted %
Age in years						
6-11	79	16.5	79	16.7	79	16.5
12-23	133	17.3	133	18.0	133	18.0
24-35	169	20.1	169	23.1	169	20.0
36-47	170	22.9	170	23.5	170	24.1
48-59	171	24.0	171	26.9	171	25.1
Sex						
Male	384	20.6	383	22.7	384	21.9
Female	339	21.2	338	22.2	338	21.0
Residence						
Rural	520	22.3	520	24.6	520	22.9
Urban	201	16.9	201	16.9	201	17.4
Level of education of the household head*¥						
Preschool/ None	99	11.1	99	13.1	99	12.1
Primary	369	22.5	369	24.7	369	23.3
Post primary/ Vocational	188	20.2	188	21.8	188	20.7
College/ University	62	29.0	62	29.0	62	29.0
Wealth index quintiles						
Lowest	181	17.1	181	18.2	181	17.1
Second	200	34.0	199	36.2	200	34.0
Middle	133	18.0	133	21.1	134	18.7
Fourth	114	15.8	114	16.7	114	17.5
Highest	94	9.6	95	11.6	94	11.7
TOTAL	**722**	**20.8**	**722**	**22.5**	**722**	**21.4**

¥ Four (4) household heads declined to state their level of education

5.7.2. Helminths in relation to anaemia in preschool children

As indicated before, parasitic infections have been found to be associated with presence of anaemia. In this study, the prevalence of anaemia, was higher in children who were free from helminth infection. This relationship is not as expected though the same has been noted in other studies. A study done in Zanzibar by Kung'u et al, in 2009 found infected children had higher haemoglobin compared with uninfected children. There was no significant difference between the preschool children with anaemia and parasitic infection including tape worm, hookworm and Schistosoma mansoni.

Table 5. 9: Anaemia among pre-school age children (6-59 months) in relation to infection with helminths

	n	Anaemia, unweighted %
Tape worms		
Present	105	22.9
Absent	415	28.0
Hook worms		
Present	112	23.2
Absent	408	27.9
Schistosoma mansoni		
Present	105	21.0
Absent	415	28.4

5.7.3. Helminths among school age children

In school aged children (SAC) the disease burden was more elevated and ranged from 24.6 percent in tapeworms, which had the lowest prevalence, to 26.0 percent in *S. mansoni* that had the highest infection rates (Table 5-10). This can be attributed to the higher reinfection rate of this demographic group owing to poor hygiene and exposure to the environment. Similarly in school age children, the distribution of infection rates by age, gender, and residence were also not statistically significant for all three infections. There was a significant difference in the distribution of infection rates for hookworm and *S. mansoni* by the level of education (preschool vs. primary and above) respectively. Again, distribution by socioeconomic status was statistically significant for each of the three infections, with the second poorest economic status bearing the largest burden. This highlights the key role sanitation plays in helminths transmission.

Table 5. 10: Helminths among school age children (5-14 years) in relation to selected demographic and economic characteristics

Characteristic	n	Tape worm, weighted %	n	Hook worm, weighted %	n	Schistosoma mansoni, weighted %
Age in years (grouped)						
5 - 11 years	572	24.3	572	25.2	572	25.2
12 - 14 years	195	25.6	195	26.2	195	28.7
Sex						
Male	363	24.5	363	24.8	363	25.9
Female	404	24.8	404	26.0	404	26.2
Residence						
Rural	581	24.4	581	26.0	581	26.7
Urban	186	25.3	186	23.7	186	24.2
Level of education						
None/Preschool	93	17.2	93	17.2	93	15.1
Primary	444	24.3	444	26.1	444	27.5
Secondary	180	26.1	180	24.4	180	25.0
College/University	41	39.0	41	41.5	41	41.5
Wealth index quintiles						
Poorest	197	17.8	197	20.3	197	19.3
Second	215	34.9	215	36.3	215	35.3
Middle	181	19.9	181	19.3	181	19.9
Fourth	112	25.9	112	25.0	112	31.3
Richest	62	22.6	62	22.6	62	24.2
TOTAL	**767**	**24.6**	**767**	**25.4**	**767**	**26.1**

5.7.4. Helminths in relation to Anaemia in School Age Children

As indicated in the Table 5-10 above and in comparison to other study groups such as preschool children and women, the highest burden of worm infestation was reported in the school age children. When these findings were correlated with anaemia, the differences noted were not significant. Helminth infection was higher in anaemic children compared to those free from infection. As noted in the preschool children, the prevalence of ID and IDA was reported to be higher in school age children free from helminth infection (Table 5-11).

Table 5. 11: Anaemia, iron deficiency, and iron deficiency anaemia among school age children (5-14 yrs) in relation to infection with helminths

Characteristic	n	Anaemia, unweighted %
Tape worms		
Present	131	17.6
Absent	476	12.6
Hook worms		
Present	136	16.9
Absent	470	12.8
Schistosoma mansoni		
Present	144	16.0
Absent	463	13.0

5.7.5. Helminths among non-pregnant women

In non-pregnant women (NPW) helminth infection rates were a little lower, compared to school age children and ranged from 14.1 percent in tapeworm to 17.2 percent in hookworm infections (Table 5-12). Disease burden distribution by age and level of education was not different for all three infections. However, there was a significant difference in the prevalence of helminth infections across the wealth quintiles with the second quintile having the highest prevalence for all the three infections and the highest quintile having the lowest prevalence for all the three infections. However, the occurrence of hookworm between rural vs urban was different with a higher prevalence in densely populated areas (urban) compared to rural for both.

Table 5. 12: Helminths among non-pregnant women (15-49 years) in relation to selected demographic and socio-economic characteristics

Characteristic	n	Tape worm, weighted %	n	Hook worm, weighted %	n	*Schistosoma mansoni*, weighted %
Age group (in years)						
15 - 19	77	18.2	77	20.8	77	19.5
20 - 49	377	13.3	377	16.4	377	14.1
Residence						
Rural	286	15.4	286	20.3	286	16.4
Urban	167	11.4	167	12.0	167	12.6
Level of Education						
Preschool/None	39	10.3	39	15.4	39	10.3
Primary	250	14.8	250	18.7	251	15.9
Post primary/ Vocational	145	13.8	145	15.9	145	15.2
College/ University	18	11.1	18	11.1	18	11.1
Wealth index quintiles						
Lowest	82	12.2	82	20.5	82	12.2
Second	97	26.8	97	30.9	97	27.8
Middle	99	11.1	99	12.1	99	12.1
Fourth	82	11.0	82	11.0	82	12.2
Highest	93	8.6	93	10.9	93	8.6
TOTAL	**453**	**14.1**	**453**	**17.2**	**453**	**15.0**

5.7.6. Helminths in relation to anaemia in non-pregnant women

Just like in preschool children, there was no significant relationship between anaemia and parasitic infestation in non-pregnant women (Table 5-13).

Table 5. 13: Anaemia, iron deficiency, and iron deficiency anaemia among non-pregnant women (15– 49 years) in relation to infection with helminths

Characteristic	n	Anaemia, unweighted %
Tape worms		
Present	84	14.3
Absent	308	21.8
Hook worms		
Present	100	19.0
Absent	292	20.5
Schistosoma mansoni		
Present	87	14.9
Absent	305	21.6

5.7.7. Helminths among pregnant women

Due to the low numbers (n=76), evaluation of trends in the frequency of helminth infections amongst pregnant women (PW) could only be undertaken by residence and ranged from 19.7 percent in tapeworm and S. mansoni to 22.4 percent for hookworm (Table 5-14). In this case, differences in rural vs. urban distribution were not statistically significant.

Table 5. 14: Percentage of Helminths in pregnant women by residence

Residence	n	Tape worm, weighted %	N	Hook worm, weighted %	n	*Schistosoma mansoni*, weighted %
Rural	48	22.9	48	27.1	48	25.0
Urban	28	14.3	28	14.3	28	14.3
TOTAL	**76**	**19.7**	**76**	**22.4**	**76**	**21.1**

5.8. Malaria and HIV Infections in the Study Population

Malaria prevalence was generally low during the survey in all age categories (<4 percent) when diagnosed by microscopy, and ≤8 percent using the more sensitive RDTs. This may be attributed to the seasonality of malaria as KMNS was conducted prior to the short rains that is usually associated with a peak in malaria transmission. Rural preschool aged children (PSC) and rural school aged children (SAC) bore the greatest malaria burden (Table 5-16).

HIV prevalence in the study population was low with highest prevalence observed in men at 2.8 percent followed by non-pregnant women at 2.4 percent. Lowest prevalence (0.8 percent) of HIV infection was registered in school age children and pregnant women.

Table 5. 16: HIV and Malaria infection in the study population by residence

Study Group	Residence	HIV, Positive		Malaria Microscopic, Positive	
		N	Weighted %	n	Weighted %
PSC	Rural	652	1.5	604	2.6
	Urban	252	1.6	244	0.0
	Total	**904**	**1.5**	**848**	**1.9**
SAC	Rural	733	0.8	682	3.8
	Urban	256	0.8	226	0.9
	Total	**989**	**0.8**	**908**	**3.1**
PW	Rural	74	0.0	65	0.0
	Urban	45	2.2	44	0.0
	Total	**119**	**0.8**	**109**	**0.0**
NPW	Rural	413	2.7	379	0.5
	Urban	247	2.0	227	0.0
	Total	**660**	**2.4**	**606**	**0.3**
Men	Rural	52	1.9	52	0.0
	Urban	19	5.3	19	0.0
	Total	**71**	**2.8**	**71**	**0.0**

5.8.1. Malaria and HIV infection in relation to anaemia in the study population

Malarial anaemia is associated with a shift in iron distribution from functional to storage compartments, and current or recent malarial infection is associated with increased serum concentrations of erythropoietin and transferrin receptor (Verhoef *et al.*, 2002). In Kenya, intense malaria transmission occurs during the rainfall seasons with long rains occurring from March to May and short rains between October and December. The current study was carried out in the low malaria season. The proportion of malaria in PSAC was 2.2 percent and hence the contribution of malaria in this survey may not be to the same as that reported in KMIS 2010, which implied that up to 20 percent of anaemia may have been attributed to malaria.

Proportion of HIV infection in the study population was found to be 2.1%. With low proportions, the contribution of HIV in anaemia was negligible.

5.9. Haemoglobinopathies in the study population

5.9.1. Sickle Cell Disease

The overall (national) prevalence of sickle cell disease was 0.2 percent. This condition, assessed by population sub-groups, showed higher prevalence (0.6 percent) in the Pre-school age children than any other group. In fact, the only other population group in which sickle cell was manifested, after the Pre SAC, was the school age children (0.1 percent). No sickle cell disease was established in the pregnant and non-pregnant and men. Clearly, the prevalence, generally, decreases with age. In both cases of preschool age and school age children, a higher prevalence of sickle cell was in the rural than the urban residences. The age prevalence variability is consistent with findings in the studies described earlier and other studies described elsewhere in Africa.

Analysis of the current data by regions was limited in validity by the small sample, which was intended for national and not regional representation.

5.9.2. Thalassemia

Thalassaemia (homozygous) had a national prevalence of 4.4 percent, which was higher than that observed for sickle cell. Again, generally, the prevalence was highest (5.3 percent) in the preschool and decreased in the older age groups (except for the non-pregnant women). The rural residents, had a prevalence of 6.2 percent; 1.4 percent and 3.5 percent in preschool, pregnant women and men respectively. Prevalence in rural school age children and non-pregnant women were 4.0 percent and 4.4 percent respectively compared to their counterparts in urban residence with 4.9 percent and 7.8 percent respectively (Table 5-17).

Thalassaemia is prevalent in West Africa but the Mediterranean Islands carry the highest prevalence's of the trait in the world (16 percent). A very low prevalence has been reported from people in Northern Europe (0.1 percent) and Africa (0.9 percent), with those in North Africa having the highest prevalence. The national prevalence of 4.4 percent is higher than the estimated average in Africa (0.9 percent).

Table 5. 17: Sickle cell and Thalassaemia in the study population by residence

Study Group	Residence	Sickle cell, SS		Thalassaemia, Homo	
		N	Weighted %	n	Weighted %
PSC	Rural	645	0.6	631	6.20
	Urban	232	0.4	231	2.60
	Total	**877**	**0.6**	**862**	**5.20**
SAC	Rural	678	1.0	653	4.0
	Urban	227	0.0	225	4.9
	Total	**905**	**1.0**	**878**	**4.2**
PW	Rural	75	0.0	72	1.40
	Urban	38	0.0	37	0.00
	Total	**113**	**0.0**	**109**	**0.90**
NPW	Rural	377	0.0	364	4.40
	Urban	225	0.0	218	7.80
	Total	**602**	**0.0**	**582**	**5.70**
Men	Rural	144	0.0	144	3.5
	Urban	75	0.0	75	2.7
	Total	**219**	**0.0**	**219**	**3.2**

5.9.3. Haemoglobinopathies in relation to anaemia in preschool children

The number of preschool children found to have sickle cell anaemia was low as indicated in Table 5-18. With the low numbers, the test statistics to test for the relationship between the haemoglobinopathies and anaemia were not valid. Thus, there was no difference detectable in the occurrence of anaemia in preschool children with or without thalasssaemia.

Table 5. 18: Anaemia among pre-school age children (6-59 months) in relation to haemoglobinopathies

Characteristic	n	Anaemia, unweighted %
Sickle cell		
Homo	3	33.3
Hetero/Normal	719	26.6
Thalassaemia		
Homo	36	33.3
Hetero/Normal	672	26.2

5.9.4. Haemoglobinopathies in relation to anaemia among school age children

The number of school age children found to have sickle cell anaemia was low. With the low numbers, the test statistics to test for the relationship between the haemoglobinopathies and anaemia were not valid. Thus, there was no difference in occurrence of anaemia in preschool children with or without thalassaemia (Table 5-19).

Table 5. 19: Anaemia among school age children (5-14 years) in relation to haemoglobinopathies

Characteristic	n	Anaemia, unweighted %
Sickle cell		
Homo	1	100
Hetero/Normal	777	17.0
Thalassaemia		
Homo	28	32.1
Hetero/Normal	714	16.5

5.9.5. Haemoglobinopathies in relation to anaemia among pregnant women

As is the case in preschool children found to have sickle cell anaemia, there were low numbers of pregnant women with thalassaemia. Due to the low response rate in pregnant women, it was not possible to test for the relationship between the haemoglobinopathies and anaemia in pregnant women.

5.9.6. Haemoglobinopathies in relation to anaemia among non-pregnant women

In KNMS 2011, there was a significance difference in occurrence of anaemia among non-pregnant women with and without thalassaemia (Table 5-20).

Table 5.20: Anaemia among non-pregnant women (15– 49 years) in relation to haemoglobinopathies

Characteristic	n	Anaemia, unweighted %
Thalassaemia		
Homo	23	39.1
Hetero/Normal	486	21.6

5.9.7. Haemoglobinopathies in relation to anaemia among men

In KNMS 2011, there was no difference in occurrence of anaemia among men with or without thalassaemia (Table 5-21).

Table 5. 21: Anaemia among men (15– 64 years) in relation to haemoglobinopathies

Characteristic	n	Anaemia, unweighted %
Thalassaemia		
Homo	5	40
Hetero/Normal	191	9.4

5.10. Nutrient Intake and anaemia in the study population

It is generally assumed that 50 percent of the cases of anaemia are due to iron deficiency. The major cause of iron deficiency in the body is low intake of iron from the diet. A given diet may be low in iron or may contain adequate amounts of iron, which are of low bioavailability. Other nutrients necessary for haematopoiesis may also be deficient. These include folic acid, vitamins A, B_{12}, and C, protein, and copper and other minerals (WHO/UNICEF/ICCIDD, 2001).

5.10.1. Nutrient intake in relation to anaemia, ID and IDA among preschool children

In KNMS 2011, there was a significant difference in the number of preschool children with anaemia, iron deficiency and iron deficiency anaemia in relation to iron intake (Table 5-22). Preschool children with inadequate iron intake had higher prevalence of anaemia, iron deficiency and iron deficiency anaemia compared to those with adequate intake. Inadequate folate intake was also associated with iron deficiency in preschool children. There was a significant difference between children with inadequate and those with adequate folate intake, and presence of iron deficiency.

Table 5. 22: Anaemia among pre-school age children (6-59 months) in relation to adequacy in RDI of macro and micronutrients

Characteristic	n	Anaemia, unweighted %
Iron*		
Inadequate	55	40.0
Adequate	96	22.9
Folate		
Inadequate	98	33.7
Adequate	53	20.8
Vitamin B_{12}		
Inadequate	126	31.0
Adequate	25	20.0

* EAR=6.9mg/d (age 7-12 months), 3mg/d (age 1-3 years), 4.1mg/d (age 4-8 years);

5.10.2. Nutrient intake in relation to anaemia among pregnant women

The low number of pregnant women in the study population whose data on nutrient intake was available could not allow for the testing of the difference between nutrient intake and occurrence of anaemia.

5.10.3. Nutrient intake in relation to anaemia among non-pregnant women

In relation to iron intake, there was no difference in occurrence of anaemia, iron deficiency and iron deficiency anaemia in non-pregnant women in the study population. The only difference noted was in relation to intake of Vitamin B_{12} and occurrence of iron deficiency anaemia. There was a significant difference in non-pregnant women with adequate and in-adequate intake of Vitamin B_{12} in relation occurrence of iron deficiency anaemia (Table 5-23). There was no difference noted in intake of folate in relation to anaemia, iron deficiency and iron deficiency anaemia in non-pregnant women.

Table 5. 23: Anaemia among non-pregnant women (15–49 years) in relation to adequacy in RDI of macro and micronutrients

Characteristic	n	Anaemia, unweighted %
Iron		
Inadequate	68	33.8
Adequate	227	22.9
Folate		
Inadequate	208	27.9
Adequate	87	19.5
Vitamin B_{12}		
Inadequate	255	24.3
Adequate	40	32.5

CHAPTER 6: VITAMIN A DEFICIENCY

6.1. Introduction

Vitamin A is an essential fat-soluble vitamin normally stored in the liver. Retinol is the predominant circulating form of vitamin A in the blood. In response to tissue demand, it is released from the liver in a 1:1 ratio with its carrier protein, retinol-binding protein. Serum retinol levels reflect liver vitamin A stores only when they are severely depleted (< 0.7 µmol/g liver) or extremely high (> 1.05 µmol/g liver) (Hixet al. 2006). The distribution of serum retinol values in a population and the prevalence of individuals with serum retinol values below a given cut-off can provide important information on the vitamin A status of a population, and may reflect the severity of vitamin A deficiency as a public health problem especially when the degree of underlying infection or inflammation is taken into account (WHO, 2011). Vitamin A is essential for proper immune function, epithelial growth and repair, bone growth, reproduction, and normal embryonic and foetal development (CDC report, 2012).

Vitamin A deficiency (VAD) is defined as the prevalence of serum retinol values <0.70 µmol/L. Prominent signs of VAD include night blindness, corneal thinning, and conjunctival metaplasia. VAD is considered the main cause of childhood blindness in low-income countries and an important determinant in safe motherhood and in child survival. Vitamin A has been shown to reduce mortality from measles by about 50 percent, mortality from diarrhoea by 40 percent, morbidity from malaria by 30 percent and overall mortality by 23 percent (WHO, 2001).

In KNMS 2011, values presented for VAD are based on levels of retinol-binding protein (RBP) measured using the ELISA technique. Nearly all vitamin A in blood is associated with RBP and therefore RBP is used as a surrogate measure for retinol content and, thus, Vitamin A status. Retinol was measured in a sub-sample and showed strong correlation with RBP. Since clinical and sub-clinical inflammation lowers retinol concentrations, values for RBP and consequently VAD presented in this chapter have been corrected for inflammation using C-Reactive Protein (CRP) and α1-acid glycoprotein (AGP) to allow for more accurate interpretation of VAD (Erhardtet al., 2004; Gamble et al., 2001).

6.2. Vitamin A Deficiency in Pre-School Children (6-59 months)

The prevalence of vitamin A deficiency corrected for inflammation is presented by two cut off levels i.e. for those persons whose serum retinol levels were <0.7µmol/L and those who had levels ≥0.7 and ≤1.05µmol/L indicative of marginal vitamin A deficiency (Table 6-1). The crude national prevalence of VAD (considering the combined sub-populations studied) was (4.5 percent). Pre-School Age Children had the highest (9.2 percent) prevalence of VAD, followed by pregnant women (5.4 percent). The levels among SAC were almost half (4.7 percent) those reported among PSC.

Amongst all age groups, the overall prevalence of marginal vitamin A deficiency was 24.2 percent. When marginal VAD in men was excluded, national marginal VAD was reported as 23.8 percent.

In pre-school children in the 1999 survey the reported prevalence in severe VAD of 84.4 percent (Mwanikiet al., 1999), regardless of the 1999 report using a lower cut-off point. The cut-off

points used were, VAD ≤10 µg/dl (≤0.35 µmol/L); and 10-20 µg/dl (0.35 to 0.7µmol/L) for moderate and >20 µg/dl (>0.7 µmol/L) for normal (WHO 1996). However, serum retinol in the 1999 survey was not corrected for inflammation and VAD is therefore likely to have been overestimated, making comparison with the 2011 survey results difficult.

In the 2011 KNMS, VAD is not a problem of severe public health significance in pre-school aged children. However, given the reasonable number of PSC at risk (with marginal VAD proportion of 52.6 percent), these children could easily transit to VAD. The high percentage of SAC at risk of VAD (marginal VAD of 37.6 percent) may also easily transit to severe VAD. The observed proportions are also lower compared to the global estimates of 33.3 percent in pre-schoolers. It is possible therefore to attribute the gains made so far to the various intervention efforts by the MOH including blanket vitamin A supplementation for pre-schoolers, food fortification and dietary diversification.

Table 6. 1: National Prevalence of Vitamin A Deficiency Corrected for inflammation

Study group	N	VAD[1], % (95% CI)	Marginal VAD[2] % (95% CI)
PSC	918	9.2 (7.3, 11.1)	52.6 (49.4, 55.8)
SAC	942	4.7 (3.4, 6.1)	37.6 (34.5, 40.7)
NPW	632	2.0 (0.9, 3.1)	7.8 (5.7, 9.9)
PW	111	5.4 (1.2, 9.6)	21.6 (14.0, 29.3)
Men	257	0.0 (0.0, 0.0)	2.0 (0.3, 3.7)
Total	**2898**	**4.5 (4.0, 7.4)**	**24.2 (21.3, 27.5)**

1 RBP<0.7µmol/L;
2 RBP ≥0.7 µmol/L - ≤1 .0 57 µmol/L

World Health Organization (2011) has derived the classification of vitamin A deficiency using the prevalence of retinol values <0.7µmol/L among children 6-71 months of age to define whether vitamin A deficiency is of public health significance in a population. The extent of public health concern is defined as mild, moderate or severe when the prevalence of low serum retinol (**0.70µmol/l or below**) is 2-9 percent, 10-19 percent and 20 percent or more respectively.

Residence of the children was one of the factors associated with occurrence of VAD in pre-school aged children (Table 6.2). Children in rural establishments were significantly less vitamin A deficient than their urban counterparts (proportions of 8.1 percent and 12.1 percent respectively). On gender differences, the male children were shown to have a higher (10.3 percent) proportion of VAD than female children (7.7 percent).

Importantly, wealth quintiles were not important determinants of VAD in pre-school aged children, compared to iron deficiency indicators. The use and interpretation of the current VAD prevalence rates has to take cognizant of the potential effect of ecological and demographic factors known to be associated with VAD such as mortality rates, full immunization coverage, mean dietary intake, prevalence of diarrhoea, nutritional status, water and sanitation among others (WHO, 2011; WHO, 2009). The government of Kenya and partners has initiated various programs which may explain VAD proportions being lower in Kenya and more so in rural areas.

Table 6. 2: Distribution of VAD in pre-school children (PSC) by demographic characteristics

Variable	N	VAD[1] %	Marginal VAD[2] %
Age in years (grouped)			
6-11 months	79	3.8	44.3
12-23 months	134	12.7	47.0
24-35 months	219	9.1	54.8
36-47 months	249	9.2	53.8
48-59 months	236	9.7	54.2
Sex			
Male	503	10.3	54.1
Female	416	7.7	50.7
Residence			
Rural	663	8.1	51.4
Urban	256	12.1	55.5
Level of education			
Preschool/None	162	11.1	48.8
Primary	446	9.4	53.6
Post primary/ Vocational	221	4.5	54.8
College/ University	85	16.5	49.4
Not stated	5	0.0	40.0
Wealth index quintiles			
Lowest	262	9.5	46.6
Second	241	9.1	53.5
Middle	150	6.7	54.7
Fourth	136	8.1	62.5
Highest	127	11.8	50.4
Total	**918**	**9.2**	**52.6**

1 RBP<0.70 µmol/L;
2 RBP ≥0.70 - <1.05 µmol/L

6.3. Vitamin A deficiency in School Age Children (5-14 years)

The prevalence of VAD and marginal VAD among school-aged children (SAC) was 3.6 percent and 33.9 percent respectively. As observed in PSC, one third of children in this age group are at risk of VAD (Table 6.3). There wasn't much difference in VAD between SAC living in rural (5.0 percent) and urban (3.6 percent) areas. The opposite was found to be the case with those of PSC, which showed lower levels for those residing in urban areas when compared with the rural residence. On gender differences, the male children were shown to have a lower (3.8 percent) proportion of VAD than female children (5.4 percent).

There is therefore need for both short-term and long-term targeted intervention efforts to fully combat VAD bearing in mind the diversity in culture, geographical and socio-economic status (Stuijvenberget al., 2011). It is important to note reasons for reversal in VAD proportions in PSC and SAC based on area of residence to develop useful VAD mitigation strategies.

Table 6. 3: Distribution of VAD in school age children (SAC) by demographics

Characteristic	N	[1]VAD %	[2]Marginal VAD %
Age in years			
5-11	296	5.6	40.7
12-14	58	1.6	27.0
Total	354	3.6	33.9
Residence			
Rural	695	5.0	36.4
Urban	248	3.6	40.7
Sex			
Male	167	3.8	37.7
Female	187	5.4	37.5
Level of education			
Preschool/None	70	8.8	35.0
Primary	224	5.4	40.9
Post primary/ Secondary	82	1.2	32.2
College/ University	61	4.6	42.9
Wealth Quintile			
Lowest	107	10.4	43.0
Second	99	1.9	38.4
Middle	68	4.9	33.5
Fourth	52	1.5	38.0
Highest	27	0.0	29.0

1 RBP<0.70 µmol/L;
2 RBP ≥0.70 - <1.05 µmol/L

Supplementation, promotion of vitamin A-rich diets and food fortification are some of the nutritional "well-being weapons" recommended by WHO. Usually, VAD develops in an environment of ecological, social and economic deprivation, in which a chronically deficient dietary intake of vitamin A coexists with infections, and frequent infections can lower intake through depressed appetite and absorption, and deplete body stores of vitamin A through excessive metabolism and excretion (WHO, 2009).

Vitamin A is fat soluble and SAC living in urban areas are exposed to food with fats/oils compared to their counterparts in the rural areas, which might be one of the explanations for the reversal in VAD between rural and urban areas.However, this explanation does not apply when it comes to PSC, whose VAD was higher in urban than rural areas(12.1 percent and 8.1 percent respectively). The government has been implementing a Vitamin A supplementation program with higher coverage in rural than in urban areas. This may explain the lower levels of VAD among PSC in rural areas. This may also explain why in PSC, level of education and wealth quantiles did not have an effect on the VAD levels, unlike in SAC where the higher the level of education and wealth quantile, the lover the VAD levels. Analysis of VAD by wealth quintiles showed a progressive decreasing trend, with people in the lowest category exhibiting the highest levels of both VAD and marginal VAD. The median age for children with VAD was 7 years, significantly lower. Child age alters the relationship between plasma RBP and retinol and may explain the decline in VAD with age. This may explain why SAC aged 5 to 12 years had a significantly higher VAD and marginal VAD than those aged 12 to 14 years.

6.4. Vitamin A deficiency in pregnant and non-pregnant women

In the adult populations, the highest VAD proportion (5.4 percent) was observed among pregnant women and reduced significantly in the non-pregnant women (1.1 percent) as indicated in table 6.1. Vitamin A requirements increases during pregnancy. The proportion of marginal VAD in pregnant and non-pregnant women was 21.6 and 8.1 percent respectively. Data for pregnant women was not segregated by socio-economic and demographic characteristics due to low response rate. The data for non-pregnant women is presented in Table 6.4.

The observed proportion in pregnant women was lower than the 15.3 percent global estimates (WHO, 2009). Physiologically, there is increased utilization of retinol in pregnancy (in meeting foetal demands), due to the physiologic adaptation of vitamin A metabolism that occurs during pregnancy related to the delivery of vitamin A to the foetus via the placenta, that results in changes in the saturation rate of RBP (Engle-Stone *et al*., 2011; Sapin *et al*., 2000). Retinol is required for normal foetal development and successful gestation. It is worth noting that haemodilution associated with later stages of pregnancy may alter interpretation of serum retinol values in pregnant women, and that other micronutrient deficiencies such as zinc required for the synthesis of RBP can cause a functional vitamin A deficiency.

When VAD was considered against the residence of the pregnant women, those residing in urban areas had a much higher (14.0 percent) deficiency unlike the rural counterparts who have no VAD deficiency (0.0 percent). Marginal vitamin A deficiency was higher in urban areas (30.2 percent) compared to 16.2 percent in pregnant women

residing in rural areas. This trend is similar to the one portrayed in PSC,, where VAD is higher in urban areas compared to rural areas.

Among non-pregnant women, VAD was higher (3.3 percent) in the age group of 15-19 years compared to 0.6 percent in the older women aged 20-49 years. On education levels and residence, women with primary school and residing in rural areas presented with highest levels of severe VAD (2.0. percent and 1.8 percent respectively. Wealth quintile did not have a significant impact on VAD among non-pregnant women.

Table 6. 4: Distribution of VAD in non-pregnant women by demographic characteristics

Characteristic	n	[1]VAD, %	[2]Marginal VAD, %
Age in years (grouped)			
15-19	122	3.3	7.4
20-49	510	0.6	8.2
Level of education			
Preschool/None	68	0.0	7.4
Primary	345	2.0	7.0
Post primary/ Vocational	178	0.0	10.7
College/ University	41	0.0	7.3
Residence			
Rural	397	1.8	8.1
Urban	236	0.4	8.1
Wealth quintiles			
Lowest	121	0.0	4.1
Second	129	3.1	11.6
Middle	123	0.8	14.6
Fourth	111	1.8	9.0
Highest	148	0.0	2.0
Total	**632**	**1.1**	**8.1**

1 RBP<0.70 µmol/L,
2 RBP≥0.70 - ≤1.05 µmol/L

6.5. Vitamin A Deficiency in Men

The men assessed only presented a marginal vitamin A deficiency of 2.0 percent without any prevalence of Vitamin A deficiency. Area of residence did not have any significance difference in men's VAD status. Not much has been reported on VAD in men in the Kenyan population. However, a study by Mathenge et al., (2007) found vitamin A deficiency as a significant public health problem among Kenyan male prisoners, indicating that it is important to track VAD prevalence among all vulnerable groups and not just young children and pregnant or lactating women.

6.6. Relating Dietary and biochemical data

Nutritional intake is likely to be directly correlated with the biochemical presence of vitamins in the body. We looked at this relationship between dietary and biochemical data to estimate specifically the prevalence of dietary vitamin A inadequacy and prevalence of vitamin A deficiency with the assumption that estimated dietary vitamin A requirements are set at levels intended to prevent an insufficient supply of vitamin A to tissues, and if not met will contribute to vitamin A deficiency. Information regarding biochemical indicators and use of 24 hour recall for PSC and non-pregnant women is provided in Table 6.5. However, the limited number limits interpretation.

Table 6. 5: Levels of Vitamin A deficiency among pre-school children (6-59 months) and non-pregnant women (15-49 years) in relation to adequacy in RDI of micronutrients

Micronutrient derived from 24 hour recall	n	[1]VAD %	[2]Marginal VAD %	n	[1]VAD %	[2]Marginal VAD %
	PSC			Non-pregnantwomen		
Adequacy						
Inadequate	112	8.0	53.6	162	0.6	7.4
Adequate	56	7.1	55.4	154	0.0	9.7

1 RBP <0.70 µmol/L;
2 RBP ≥0.70 - <1.05 µmol/L

CHAPTER SEVEN: IODINE

7.1. Introduction

Iodine is found in the environment all over the world, predominantly as iodide. However, its geographical distribution is quite uneven. Quantitatively, most iodide is found in the oceans because of flooding, glaciation and erosion, which have led to a washout of the element from many surface soils. On average, ocean waters contain about 50µg/L of iodide. There is a continuous ecological cycle in which iodide from the oceans evaporates into the atmosphere (air contains about 0.7µg/m^3) and is brought back to replenish the inland areas by rain (rainwater contains 0.3-0.7µg/L). This cycle is slow, however, and the soils, groundwater and foods grown in many regions are low or lacking in iodine. Plant crops grown in iodine-deficient soils can have iodide content as low as 10µg/kg, compared to plants from iodine-sufficient soils which can contain as much as 1mg/kg, a 100-fold difference. In contrast, many foods of marine origin, especially shellfish, contain high iodine contents because of the ability to assemble iodide from their prey and seawater Koutras et al 1980).

Iodine from the diet is required by the human body for the synthesis of thyroid hormone in the thyroid gland. Other dietary substances, named goitrogens, can worsen the effect of an iodine-deficient diet as they interfere with iodine absorption or with the take-up and conversion to thyroid hormone in the thyroid gland. Cruciferous vegetables such as cabbage, kale and rapeseed, contain glucosinolates, which are compounds that compete with iodide for uptake in the thyroid grand.

A major function of thyroid hormone is in regulating cell growth and differentiation in the unborn and newborn early life. Also the metabolism of proteins, carbohydrates and lipids during all life stages depends on thyroid hormone. Due to the rapid growth and differentiation of the brain cells in the fetus and during early infancy, the most damaging effects of iodine deficiency concerns the developing brain of the fetus and young children, depressing the children's learning ability and handicapping their prospects for productive earnings in later life. Even mild iodine deficiency may be causally involved in cognitive impairment of children (Zimmermann et al., 2008). In 2011, the largest proportions of children with insufficient iodine intake were in Europe (43.9 percent) and Africa (39.3 percent), while the Americas and Western Pacific had the smallest proportions at risk at 13.7 percent and 18.6 percent, respectively. It was estimated that about 1.88 billion people globally had insufficient habitual iodine intakes from the diet to meet dietary recommendations, which is a 6.4 percent reduction since 2007, but still more than one-quarter of the world's total population (Anderson et al., 2012).

7.2. Iodine Nutrition in Kenya

A national nutrition survey carried out between 1962 and 1964 reported very high goiter rates of 15-72 percent, with the highest rates goiter burden in the highlands of the Rift Valley, Nyanza and Western provinces Gitau et al., 1988). Salt iodization was started in 1970 as a preventive measure for goiter on voluntary basis at 20mg/kg (iodine parts per million), based on an assumption that the average salt intake in Kenya was 10g per person per day. In 1973, the amount of iodine to be added to iodized salt was increased to 30mg/kg after realizing that the daily salt intake was less, i.e., about 5g on average. Subsequent studies showed an increase in urinary iodine concentrations but this was not accompanied by a corresponding decrease in goiter prevalence.

Gitau carried out a comparative study in 1984 to assess the effectiveness of the (increased) salt iodization level on goitre and urinary iodine concentration in localities of Kiambu, Kericho, Nairobi and Mombasa. The goiter prevalence was highest in Kericho at 55%, followed by Kiambu at 21%. Nairobi had a prevalence of 20% while in Mombasa no goiter was observed.

In 2010, upon suggestions of high iodine nutrition indicators in a 2004 National Survey, Kenya enacted a revised standard for the iodization of salt at production, a reduction from 100 to 30-50mg iodine/kg salt, while compelling the use of potassium iodate as fortificant. Therefore, one of the underlying purposes of the 2011 micronutrient survey was to collect indicator data from selected target groups to assess that the newly adopted standard provides adequate iodine supplies and status in the population.

7.3. Methods

KNMS field workers collected spot urine samples of school-age children (SAC) and non-pregnant women of reproductive age (NPW) and, in addition, salt was sampled in the households of the enrolled participants. The urine samples were analyzed in CPHR for the iodine (UIC) as well as the sodium concentration (UNaC), and the consumer salt samples were measured in NPHL for iodine content (SI). The laboratories of both institutes applied recommended quality control procedures to limit analytical variation (UIC and SI were measured with less than 5% total analytical error). The UIC and SI data were verified for accuracy by a 3-way inter-laboratory comparison with two accredited iodine laboratories in Tanzania and Kazakhstan. The iodine laboratory at CPHR received a certificate of successful performance during the period of processing of the KNMS urine samples from the external laboratory quality service program EQUIP, managed by CDC, Atlanta, USA.

Estimating the Sources of Iodine Intake

In a salt producer's value chain, iodized salt is either directly sold to the consumer markets (consumer salt fraction) or sold to customers and traders who, in turn, supply the processing industry (food industry salt fraction). These two key salt supply channels come together in the customary diets and augment the iodine already present in native foods (native iodine fraction), in combination leading toward a total iodine intake that intends to satisfy the biological iodine requirements throughout all the segments of a population.

The KNMS protocol included the intent to estimate the supply sources of iodine in the common diet. The KNMS became the first large-scale micronutrient survey worldwide that added sodium measurements (the main discerning element of salt intake) in the same urine samples collected for iodine status assessment. By combining the two urinary parameters together with the SI content in salt from the respondent's households, the survey intended to enable a separation of the population's dietary iodine intake into its constituent iodine supply sources from native diet, food salt and consumer salt.

7.4. Statistical Analysis

The two indicators measured in urine samples were the UIC (expressed in µg iodine/L) and the UNaC (mmol sodium/L). SI (mg iodine/kg salt) was measured in salt samples collected from the enrolled participants' households. All data analyses were weighted to account for non-participation due to refusal, absence from the household and missing data. The UIC findings are reported using medians and interquartile ranges (IQR), whereas for UNaC and SI the means and their 95% confidence intervals were obtained. The iodine indicators were categorized across different levels of selected co-factors age, gender, residence, province and wealth index, as applicable. Pearson's Chi-Square test was used to express the strength of association.

7.5. Urinary Iodine Concentration (UIC)

According to the World Health Organization, the median UIC is the main indicator to be used to assess the iodine nutrition situation of a population (WHO, 2013). Since it is overly cumbersome to accurately collect 24-h urines under field conditions, UIC was measured in spot urine specimens from a representative sample of each target group, and expressed as group median in µg/L. There are different hydration levels and diurnal variations in UIC between individuals, but these even out in a large number of samples, making the median UIC in spot samples from groups of individuals correlate with the iodine intake findings from 24-h urine collections(Zimmermann et al 2009).

The UIC values, presented in table 7-1a and 7-1b, were categorized in line with current Iodine Global Network (IGN) recommendations. Table 7-1a shows the distribution parameters of UIC levels among the school age children of Kenya. The median UIC (µg/L) for all SAC was 208µg/L, which is in the range considered adequate by international agreement. Gender, residence, province and household wealth were significant factors influencing the SAC distributions of UIC. The median UIC values in boys (231µg/L) and girls (199µg/L) differed significantly but

Table 7. 1a: Urinary Iodine Concentration in school age children, KNMS 2011

Characteristic	N	Median µg/L	IQR*		0 – 99 µg/l (%)	100-299 µg/l (%)	300-499 µg/l (%)	≥500 µg/l (%)
Age								
5 - 8 years	431	200	109	310	21	51	18	10
9 - 14 years	518	217	107	348	23	45	18	15
Gender								
Male	478	231	118	368	19	45	21	15
Female	473	191	99	294	25	50	14	11
Residence								
Rural	699	188	99	327	25	46	15	14
Urban	252	231	153	341	14	51	25	10
Province								
Nairobi	49	209	169	313	6	55	38	2
Central	97	244	130	348	18	40	28	13
Coast	78	294	170	481	8	46	23	23
Eastern	139	240	178	457	9	50	19	22
N/East	77	846	303	1,157	3	19	13	65
Nyanza	138	122	88	222	30	61	8	1
Rift Valley	258	151	81	275	36	46	16	2
Western	115	164	72	245	32	53	12	3
HH wealth index								
First	241	221	106	349	23	45	16	16
Second	270	143	83	243	32	48	14	6
Middle	206	231	121	397	20	45	14	20
Fourth	135	224	155	347	10	61	22	7
Fifth	99	294	192	409	11	39	33	16
All SAC	951	208	108	333	22.1	47.5	17.6	12.8

* Interquartile Range; P25 to P75

were both within the range of 100-299µg/L, considered adequate. Similarly, the median UIC values of children in the rural (188µg/L) and urban areas (231µg/L) were different and within the boundaries of adequate iodine nutrition. The UIC findings in children across provinces vary substantially with very high values in North-Eastern province and the lowest, though sufficient, values in Nyanza, Rift Valley and Western provinces. SAC's UIC values also differed significantly among household wealth categories, mainly due to lower UIC values (143µg/L) in the SAC from poorer households (HHW=2) as compared to the wealthiest households (median UIC 294µg/L). Overall, UIC values below 100µg/L were found in 22.1 percent of SAC, while 30.4 percent had UICs of 300µg/L or more. Approx. half of the UIC values of the SAC in Kenya were within the boundaries of optimal iodine nutrition (100-299µg/L) recommended by IGN.

The overall median UIC in the non-pregnant women of Kenya was 168µg/L, which is in the adequate range agreed internationally. Classification of the UIC values by age group did not generate a significant difference between the NPW of <20 and ≥20 years. The UICs of NPW separated by residence, though statistically different, indicate adequate iodine nutrition status in both the rural (163µg/L) and urban (180µg/L) NPW groups. Similar as in SAC, the classification of UIC values in NPW by household wealth index showed significant differences due to lower UICs (132µg/L) in women from poorer households (HHW=2) as compared the wealthiest households (202µg/L). And again, similar as in SAC, the variation of UIC values in NPW differed significantly by province, with highest UICs in North-Eastern Province and lowest in Western, Rift Valley and Nyanza provinces.

Table7-1b: Urinary Iodine Concentration in non-pregnant women, KNMS 2011.

Characteristic	n	Median µg/L	IQR*		0 – 99 µg/l (%)	100-299 µg/l (%)	300-499 µg/l (%)	≥500 µg/l (%)
Age								
<20 years	119	168	104	287	20	61	13	6
>20 years	504	164	97	305	27	47	17	9
Residence								
Rural	389	163	91	279	30	47	16	8
Urban	234	180	125	321	18	55	17	10
Province								
Nairobi	65	252	171	402	9	47	30	14
Central	76	222	117	367	15	51	19	16
Coast	54	220	133	368	10	51	18	21
Eastern	91	203	111	310	21	49	21	9
N/East	30	372	231	609	0	36	37	27
Nyanza	85	148	86	244	32	51	13	4
Rift Valley	159	138	80	165	36	56	7	1
Western	101	98	64	172	52	41	7	0
HH wealth index								
First	114	163	98	384	27	39	22	12
Second	130	132	67	226	42	46	9	4
Middle	120	145	98	225	25	58	13	5
Fourth	111	155	105	297	23	52	16	8
Fifth	148	202	134	359	12	53	22	13
All SAC	623	168	98	299	25.6	49.7	16.2	8.6

* Interquartile Range, P25 to P75

Nearly half of the UIC values in NPW fell in-between the boundaries of optimal iodine nutrition (UIC 100-299µg/L) as per IGN recommendation.

7.6. Urinary Sodium Concentration (UNaC)

Like many countries in Africa and in other parts of the world, Kenya's USI strategy is devised to meet the iodine requirements of its population through the iodization of all the salt intended for human consumption, meaning that the iodine status of Kenya's population is directly linked with the consumption of salt, the main dietary supply "vehicle" to ensure iodine intake. In the KNMS, the urinary sodium concentration (UNaC) was measured in spot urine samples in complement to the urinary iodine measurements. Combined analysis of the UIC and the UNaC in a large cohort allows a more refined examination of the iodine nutritional status by estimating the contribution made by the consumption of iodized salt in the population's iodine intake (Haldiman et al., 2015). As suggested previously (McLean RM et al., 2014), the use in large surveys of a single spot urine collection has many potential advantages, as it is able to be collected in a single encounter, thereby bypassing the need for multiple visits (Hawkes C and Webster J, 2012) .

The UNaC distribution shares in SAC and NPW are reported in accordance with the nomenclature recommended by the World Hypertension League (WHL) for classification of the salt intake in adults (Campbell NRC et al., 2015).

UNaC findings of the Kenyan SAC and NPW are shown in Tables 7-2a and 7-2b. The mean UNaC in SAC was 192mmol/L; 95% CI: 185-199mmol/L. Significant differences in UNaC values existed between age group, gender, urban/rural residence and household wealth index. SAC aged 9 to 14y had higher mean UNaC (203mmol/L) compared their younger peers (178mmol/L). The mean UNaC was also higher in male children (209mmol/L), children residing in urban areas (221mmol/L) and in the wealthiest households (236mmol/L), each in comparison to their respective counterpart groups.

Almost half of the female (47%) and more than half (63%) of the male SAC had UNaC values >174mmol/L, indicative of very high sodium intake using a classification of the World Hypertension League for adults. Very high UNaC values were also found in older children (61% of UNaC values), as well as children residing in urban areas (61%) and in the wealthiest households (69%). Also the differences in UNaC values of SAC were sizable across Provinces of Kenya; to illustrate, the mean UNaC ranged from 146mmol/L in Western Province to 241mmol/L in Coastal Province, a difference of approx. 50%.

Table7-2a: Urinary Sodium Concentration in school-age children, KNMS 2011.

Category	n	Mean	95% CI		UNaC distribution shares (as per WHL)			
					Normative <87	High 87-174	Very high 174-261	Extreme ≥261
					%	%	%	%
Age								
5 to 8y	386	178	167	to 188	22	32	22	24
9 to 14y	477	203	194	to 213	18	21	30	31
Gender								
Male	424	209	199	to 219	14	23	28	35
Female	439	176	165	to 186	25	28	26	21
Residence								
Rural	635	182	174	to 190	23	25	29	23
Urban	228	221	206	to 235	10	28	21	41
Province								
Nairobi	45	224	202	to 245	3	31	26	40
Central	88	194	174	to 214	13	35	23	29
Coast	71	241	210	to 272	15	18	21	46
Eastern	126	226	208	to 244	10	20	32	38
N/Eastern	70	210	182	to 238	19	12	38	31
Nyanza	125	184	168	to 200	17	28	33	21
Rift Valley	233	171	157	to 185	26	30	22	22
Western	104	146	128	to 165	36	25	23	16
HH wealth								
Poorest	224	180	167	to 193	19	27	36	17
HHW=2	234	164	150	to 178	32	25	19	25
Middle	189	203	189	to 218	19	21	27	33
HHW=4	125	217	199	to 236	7	35	25	32
Wealthiest	90	236	213	to 260	8	23	25	45
All SAC	863	192.0	184.8	to 199.2	20	26	27	28

Table7-2b: Urinary Sodium Concentration in non-pregnant women, KNMS 2011

Category	n	Mean	95% CI		UNaC distribution shares as per WHL			
					Normative <87	High 87-174	Very high 174-261	Extreme ≥261
					%	%	%	%
Age								
Up to 19y	108	218	201	to 236	11	19	35	35
≥20y	470	178	169	to 187	19	29	31	21
Residence								
Rural	361	175	164	to 185	22	30	29	20
Urban	218	204	192	to 215	11	24	37	29
Province								
Nairobi	61	231	213	to 249	5	8	53	34
Central	71	197	177	to 217	7	37	33	23
Coast	47	218	187	to 249	16	23	24	36
Eastern	84	221	203	to 239	6	18	44	32
N/Eastern	28	198	157	to 240	4	43	19	34
Nyanza	79	193	169	to 218	19	29	23	28
Rift Valley	148	149	135	to 163	28	33	29	10
Western	61	125	102	to 149	40	27	22	11
HH wealth								
Poorest	99	186	166	to 206	17	29	31	23
Next	131	149	132	to 167	31	30	22	17
Middle	109	177	160	to 194	20	27	37	16
Next	110	189	171	to 208	16	35	22	27
Wealthiest	130	226	212	to 240	4	18	45	33
All NPW	579	185.5	177.6	to 193.4	18	27	32	23

NPW had a mean UNaC of 186mmol with 95 CI: 178-193mmol/L. The UNaC mean values and the UNaC distribution parameters in NPW, similar as in SAC, showed sizable differences between age group, urban/rural residence and household wealth index. The younger age group of NPW had a higher UNaC values than older women and the UNaC in urban areas (204mmol/L) exceeded the rural UNaC (175mmol/L). Further, women in the wealthiest households (226mmol/L) had higher UNaC than their counterpart group (149mmol/L) in poorer households (HHW=2). By Province, NPW in Nairobi had the highest (231mmol/L), while NPW in the Rift Valley (149mmol/L) and Western Province (149mmol/L) had the lowest mean UNaC. In terms of the WHL nomenclature, 55 of the UNaC values in NPW suggested very high salt intakes. Very high UNaC values were particularly prevalent among <19y-old NPW (70), women in urban areas (65), in the wealthiest households (78) and in Nairobi (87) province.

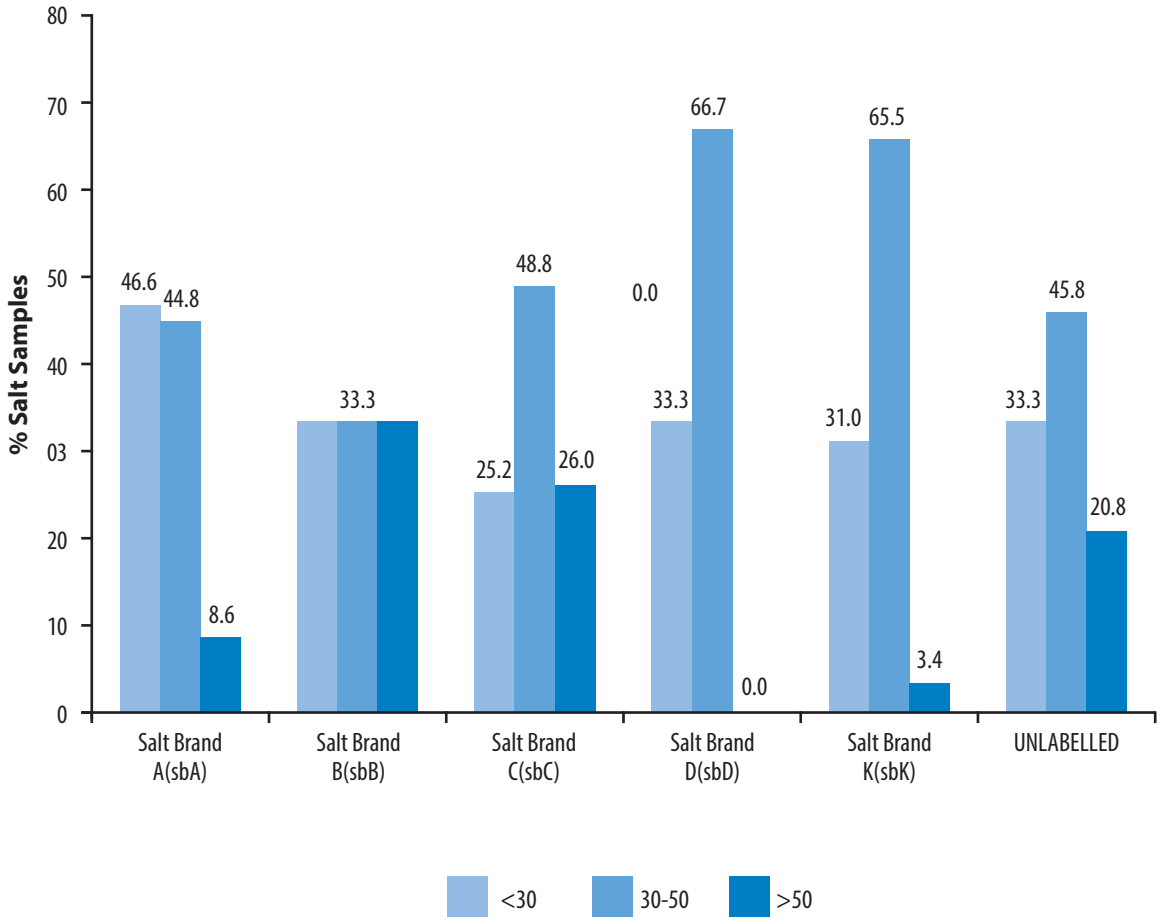
Noteworthy, the UNaC and UIC levels, both in the SAC and the NPW, appeared to exhibit a mutually related pattern of co-variation. High median UIC along with high mean UNaC were found in the women and children in urban areas and in the highest household wealth quintiles whereas, in contrast, the lowest UNaC as well as lowest UIC values were found in rural areas, asset-poorer households (HHW index=2) and in the Rift Valley and Western Provinces. The observed pattern would suggest existence of a functional relationship between the dietary intakes of salt and iodine in the Kenyan population groups. This relationship is explored further in a later section of this report.

7.7. Iodine Content in Consumer Salt

A total of 627 salt samples from 11 brands collected from households with SAC or NPW were analysed for salt iodine (SI) content. Because sampling weights for SI were not relevant for descriptive parameters, the findings are presented directly and in comparative fashion. The major KNMS findings of SI content are reported in a separate Chapter which addresses Kenya's food fortification strategies. The mean SI content was 40.8mg/kg (SD 19.6). Only 4 of the consumer salt specimen had SI values below 15mg/kg, which is the cut-off criterion by international convention. The findings of iodine content in the salt used in the households of Kenya during the 2011 KNMS show 96 household coverage with adequately iodized salt, thus confirming that the USI target was successfully accomplished.

For comparisons of SI levels by industry source (i.e., salt brands), the SI distribution was classified according to the Kenyan salt iodization standard where 30 -50mg iodine per kg salt is regarded as adequately iodized while <30mg/kg and >50mg/kg are inadequately and over-iodized, respectively. Slightly less than half (48.3) of all the consumer salt samples were found iodized in accordance with the Kenyan standard. Salt samples with iodine levels below 30mg/kg were 29.2 while 22.5 had iodine levels higher than 50mg/kg, within a total range for household SI values of 1.6 to 150.2mg/kg.

Figure: 7. 1: Iodine content in household salt samples by salt brand and category



Of the branded salt specimen collected from the households, salt brand sbC had the highest number of samples followed by sbA and sbK. Figure 7-1 of SI findings by brand shows that approx. three-quarters of the sbD and sbK samples were adequately iodized, compared to close to half of sbC. At 46.6, sbA reported the highest number of inadequately iodized salt, while sbC (25.2) and sbK (31.0) had the lowest proportions of inadequately iodized salt samples. A considerable proportion of the sbC samples (26.0) had iodization above the standard compared to sbK (3.4) and sbA (8.6). Among the consumer salt collections, 96 did not have a brand name mainly because the salt had been transferred into different containers from the original package. Of the unlabeled salt, 45.8 were within the salt iodization standard, 33. 8 had less than 30mg/kg while 20.8 had more than 50mg/kg iodine.

No significant difference in proportions of adequacy was found between the salt samples from urban and rural areas; 47.3 and 50.0 of the salts in rural and urban areas were adequately iodized respectively. Nevertheless, more consumer salt in the rural households (31.8) was having SI levels below 30mg/kg compared to urban areas (25.0).

Table 7. 3: Distribution of Salt iodine by demographic characteristics and brands

	n	<30 ppm	30 - 50 ppm	>50 ppm
		%	%	%
Residence				
Rural	387	31.8	47.3	20.9
Urban	240	25.0	50.0	25.0
SALTBRAND				
A	29	31.0	65.5	3.4
B	420	25.2	48.8	26.0
C	58	46.6	44.8	8.6
UNLABELLED	96	33.3	45.8	20.8
OTHERS	24	37.5	37.5	25.0
TOTAL	**627**	**29.2**	**48.3**	**22.5**

CHAPTER EIGHT: ZINC DEFICIENCY

8.1. Introduction

Zinc deficiency is among the most important causes of morbidity in developing-country settings. From the 1999 National Survey report, approximately 50% of both children and women had serum Zinc levels below 65µg/L. Serum or plasma zinc concentration is the best available biomarker of risk of zinc deficiency in populations. In this study plasma zinc was used for biochemical analysis. The cut-offs used (Table 8-1) for the different population groups were as defined by the WHO/UNICEF/IAEA/IZiNCG (2007). A prevalence, for low serum zinc, of between 10 percent and 20 percent suggests that some segments of the population may be at high risk of zinc deficiency (Brown et al 2004). , (Refer to Chapter 2, Correction for inflammation section).

Table 8. 1: Cut-offs for serum zinc concentration (µg/dL*) for morning and non-fasting

Study Group	Age / Pregnancy stage	Lower cut-off µg/dL
Pre SAC	<5 years	65
SAC	<10 years (boys & girls)	65
	≥10 years (Boys)	70
	≥10 years (Girls)	66
Men	≥10 years	70
Non-Pregnant Women (NPW)	≥10 years	66
Pregnant Women (PW)	1st trimester	56
	2nd& 3rd trimesters	50

*For conversion to µmol/L, divide by 6.54 (IZiNCG; 2012)

8.2. Zinc Deficiency in Pre-School Children (6-59 months)

In children, the risk of zinc deficiency increases with the introduction of complementary foods, as these foods are mainly cereal based, which have lower nutrient densities (Veenemans, 2011). Complementary foods also contain high concentrations of phytates and polyphenols that inhibit the intestinal absorption of dietary zinc. This survey established a median plasma zinc concentration levels 50µg/dL ranging between 38 and 59 µg/dL.

Of all children 6-59 months, 83.3 percent had low plasma zinc, which is an indication of zinc deficiency among pre-school children being a major public health issue (Table 8-2). The difference in plasma zinc concentration between children 23 months and below and those aged 24-59 months was not significant. This observation was similar among boys and girls. However, the prevalence of zinc deficiency differed significantly across wealth quintiles where those children from poorer households had a high prevalence (89 percent) compared to those from richer households (75 percent). Further, zinc deficiency was significantly higher among children who resided in the rural areas compared to those in urban areas.

Table 8. 2: Distribution of plasma zinc concentration for Pre-school age children (Pre-SAC)

Variable	N	Median	IQR*		Min	Max	% with low serum zinc
Age group in months							
6 - 23	142	48	38	57	13	89	85.3
24 – 59					1	252	82.8
Gender							
Male	417	50	38.4	59	1	252	82.3
Female	351	51	38	58	1	205	84.6
Residence							
Rural	556	49	38	57	1	173	86.0
Urban	212	53	39.8	62	11	252	76.4
HH wealth index							
Lowest	227	48	36.5	57	4	123	89.0
Second	197	50	37	58	1	173	86.8
Middle	116	47	38	57	1	205	85.3
Fourth	118	52.20	38	66	12	252	72.0
Highest)	110	56.20	45.4	64	12	115	75.7
Total	**768**	**50**	**38**	**59**	**1**	**252**	**83.3**

*IQR = Interquartile range

On average, stunted children had lower serum zinc concentration (median of 47 µg/dL) compared to the rest of the children (median of 52 µg/dL). There was no significant positive linear correlation between stunting (HAZ scores) and zinc concentration. The overall prevalence of zinc deficiency among Pre-SAC in this 2011 Survey (83.3 percent) was higher than that reported in the 1999 National Survey (50.8 percent) as well as among Tanzanian children (67 percent) of the same age (Veenemans, 2011).

8.3. Zinc deficiency in School Age Children (5-14 years)

The overall prevalence of zinc deficiency among School Age Children (SAC) was 80.2 percent with a median serum zinc concentration of 53 (IQR 45-63µg/dL) (Table 8-3). This deficiency ranged, in prevalence, from 79.9 percent for SAC aged 5-9 years to 80.4 percent among those aged 10-14 years. Boys had a significantly higher prevalence of zinc deficiency compared to girls of the same age. SAC living in rural areas had a significantly higher prevalence of zinc deficiency (82.5 percent) compared to those living in urban areas (73.6 percent). A decreasing trend in prevalence was noted as the wealth quintiles increased, except for the middle wealth quintile, which registered the highest prevalence of zinc deficiency (87.1 percent).

Table 8. 3: Prevalence of serum zinc concentration for school aged children (SAC)

Variable	n	Median	IQR*	Min	Max	% with low serum zinc
Age category						
5 - 9 years	537	53	45 - 61	8	291	79.9
10 - 14 years	428	54	47 - 64	3	380	80.4
Gender						
Male	471	53	45 - 61	12	291	83.0
Female	492	54	46 - 64	3	380	77.2
Residence						
Rural	713	53	44 - 62	3	380	82.5
Urban	254	54.4	49 - 66.8	8	206	73.6
HH wealth index						
Lowest	256	52	43 - 59	3	136	85.5
Second	268	53	46 - 63.9	16	380	78.0
Middle	200	52.4	44 - 59	12	206	87.0
Fourth	143	54	48 - 65	27	128	74.1
Highest	99	58	51 - 69.6	8	185	67.7
Total	**967**	**53**	**45 - 63**	**3**	**380**	**80.2**

*IQR = Interquartile range

8.4. Zinc Deficiency in Pregnant Women

The overall prevalence of zinc deficiency in pregnant women (Table 8-4) was 68.3 percent, which was higher than that reported in 1999 National Survey (52 percent). Pregnant women in their 2nd /3rd trimester had a higher prevalence of zinc deficiency (69.4 percent) than those in their 1st trimester (60.7 percent). Though pregnant women residing in urban areas had high prevalence of zinc deficiency (70 percent), than those in the rural areas (67percent), there were no differences registered, in prevalence of zinc deficiency, between the various wealth quintiles.

Table 8. 4: Distribution of serum zinc concentration for pregnant women (PW)

Variable	n	Median	IQR*		Min	Max	% with low serum zinc
Pregnancy stage							
1st Trimester	28	50.5	41	58	14	114	60.7
2nd & 3rd Trimester	85	42	36	54	19	191	69.4
Residence							
Rural	75	43.5	37	57	14	191	67.1
Urban	47	40.5	40	56.3	19	125	70.2
HH wealth index							
Poorest	26	47	38.5	57.5	14	191	57.7
Second	35	43.9	37	57	19	159	68.6
Middle	21	41.3	36	56.2	30	125	71.4
Fourth	17	38. 5	31.9	39	31	67	94.1
Richest	22	46	39	59.2	19	114	59.1
Total	**122**	**43**	**36**	**57**	**14**	**191**	**68.3**

*IQR = Interquartile range

8.5. Zinc Deficiency in Non-Pregnant Women

The overall prevalence of zinc deficiency in non-pregnant women was 82.3 percent (Table 8-5) with over three quarters of all NPW showing low serum zinc concentration. There was no difference in prevalence of zinc deficiency among non-pregnant women residing in rural with those living in urban areas (82.4 percent).

Table 8. 5: Distribution of serum zinc concentration for non-pregnant women (NPW)

Variable	n	Median	IQR*		Min	Max	% with low serum zinc
Residence							
Rural	409	53	46	60.5	16	287	82.4
Urban	244	55	43.7	63	10	219	82.4
HH wealth index							
Poorest	124	54.6	44	59	19	101	87.1
Second	133	54	47	64.3	22	287	76.1
Middle	124	50	44	60	16	141	87.9
Fourth	117	52	43	59.7	22	235	82.2
Richest	154	55.6	46	64	10	219	79.2
Total	**653**	**54**	**44**	**61.5**	**10**	**287**	**82.3**

*IQR = Interquartile range

8.6. Zinc Deficiency in Men

The overall prevalence of zinc deficiency among men was 74.8 percent (Table 8-6). Area of residence did have a significant difference in the prevalence of zinc deficiency ($p<0.05$). Men in rural areas had a significantly higher prevalence of low serum zinc concentration (79.7 percent) than in the urban areas where about two-thirds had zinc deficiency (67 percent).

Table 8. 6: Distribution of serum zinc concentration for men

Variable	n	Median	IQR*		Min	Max	% with low serum zinc
Residence							
Rural	158	60	49	67	10	148	79.7
Urban	100	63	48	76	19	687	67.0
HH wealth index							
Poorest	40	60	47.5	63.8	10	125	87.5
Second	64	62	48.4	66	29	148	78.1
Middle	44	61	50	67	30	687	84.1
Fourth	62	52	33	63.8	19	219	79.4
Richest	47	74	62	82	23	118	44.7
Total	**258**	**61.1**	**48.8**	**69.6**	**10**	**687**	**74.8**

*IQR = Interquartile range

8.7. Prevalence of Low Serum Zinc after Correcting for Inflammation

For all persons whose CRP and AGP values were computed, an inflammation correction factor was constituted and zinc values adjusted accordingly (See chapter 2 on correction for inflammation). After adjustment, the recommended cut-offs were applied to determine prevalence of low serum zinc (Table 8-7).

Table 8.7: Distribution of low serum zinc concentration by study group, uncorrected and corrected for inflammation

Study group	N[1]	% with low serum zinc	
		Uncorrected	Corrected for inflammation
Pre-school age children (PSC)	711	82.8	81.6
School age children (SAC)	901	80.4	79.0
Pregnant women (PRG)	109	67.9	67.9
Non-pregnant women (NPW)	617	80.7	79.9
Men	239	77.4	77.4

1 Includes only those with both CRP and AGP values and therefore the prevalence may be different when you consider all surveyed

After correcting for inflammation, the prevalence of low serum zinc decreased marginally for SAC (by 1.4 percent), PSC (by 1.2 percent) and NPW (by 0.8 percent). For men and pregnant women, the prevalence of low serum zinc remained unchanged. Although pregnant women had the lowest prevalence of low serum zinc concentration, in general men had a higher median serum zinc concentration than the rest of the population groups.

8.8. Nutrient Intake and Zinc Deficiency

Dietary intake is a good proxy indicator for estimating deficiencies in the absence of biochemical data. The need to have a varied diet with animal source foods that provide micronutrient requirements has been documented (Mbwibo and Neumann, 2003). Dietary intake data as described in chapter 10 of this report, shows that the dietary diversity among children was below the miminum recommended 4 out of 7 groups. In addition, children from rural areas had markedly higher inadequacy levels than children from urban areas and also significantly higher prevalence of low serum zinc concentration. Prevalence of inadequate zinc intake was highest among children 6-11 months (66 percent) while 17 percent of those aged 12-59 months had inadequate zinc intake. The relationship between dietary intake and zinc concentration may therefore be inferred from this survey.

CHAPTER NINE: FOLATE AND VITAMIN B_{12} DEFICIENCY IN PREGNANT AND NON-PREGNANT WOMEN

9.1. Introduction

Folate and vitamin B_{12} plays an important role in human development, and a high folate with low vitamin B_{12} plasma status combination has been associated with cognitive impairment. A deficiency of one of these vitamins alters the metabolism of the other, and folate sufficiency may mask cobalamin deficiency (WHO, 2008). Folate deficiency in women of childbearing age increases the risk of neural tube birth defects, and is associated with haematological disorders such as macrocytic anaemia (WHO, 2005; Brito et al., 2012). Folate is found naturally in plant and animal foods or added as folic acid to staple foods. Folate deficiency can arise from insufficient dietary intake as well as malabsorption due to gastrointestinal disorders and secondary deficiencies of B_6 and B_{12}. Ageing also has an impact on vitamin B_{12} absorption. Cobalamin deficiency can occur in both wealthy and poor individuals, and so deficiency occurs when intake of these foods is low. Vitamin B_{12} deficiency is certainly more prevalent in vegans, but ovo-lacto vegetarians are also at higher risk for inadequate intakes. Vitamin B_{12} concentrations in breast milk can be markedly lower in vitamin B_{12}-depleted women in comparison to folate in lactating women (WHO 2008). Vitamin B_{12} can be increased in populations through diversification of diets, supplementation and food fortification.

The most practical and least expensive measurements at the population level are serum or plasma vitamin B_{12} and folate. Diagnosis of vitamin B_{12} deficiency is typically based on measurement of serum vitamin B_{12} levels.

9.2. Folate and B_{12} deficiency among pregnant women

This survey represents results of 78 respondents for pregnant women for both folate and B_{12} which represents a response rate of 34 per cent. The findings should therefore be used with caution to represent the national prevalence of folate and B_{12} deficiency.

The national prevalence of folate deficiency in pregnant women was 32.1 percent (Table 9-1), that compared with a study in India (26.3 percent) and Venezuela (36.3 percent) (Pathak, 2007). Distribution of folate deficiency in pregnant women showed no major variability by residence however, pregnant women that dwell in urban areas had a lower prevalence (25.0 percent) than those in rural areas (36.0 percent).

The national prevalence of Vitamin B_{12} deficiency in pregnant women was 7.7 percent (Table 9-1). This is a very low prevalence compared to other reported results from developing countries (India, 74.1 percent, Nepal 60 percent and Turkey 72 percent) (Koc et al, 2006).

Table 9. 1: Distribution of Folate and B_{12} deficiency among pregnant women (15-49 years) by residence

Residence	Unweighted	Folate<10 nmol/L Unweighted			B_{12}<150 pmol/L Unweighted		
	N	%	95% C.I.		%	95% C.I.	
Rural	50	36.0	22.7	49.3	8.0	0.5	15.52
Urban	28	25.0	9.0	41.0	7.1	0.0	16.6
Total	**78**	**32.1**	**21.7**	**42.5**	**7.7**	**1.8**	**13.62**

The pregnant women that dwell in rural areas had a higher (8.0 percent) prevalence of Vitamin B_{12} deficiency compared to pregnant women in urban areas (7.1 percent).

9.3. Folate and B_{12} deficiency among non-pregnant women

The response rate of 63 percent was reported in non-pregnant women for folate and B_{12} indicators. The National prevalence of folate deficiency in non-pregnant women was 30.9 percent which was higher than that of pregnant women. There was no significant difference in the distribution of folate deficiency in terms of age, level of education and wealth quintile. However significant difference was noted in the prevalence of folate deficiency according to area of residence of the women.

Table 9. 3: Distribution of Folate and Vitamin B_{12} deficiency among non-pregnant women (15-49 years) by selected demographic and economic characteristics

Variables	n	Folate <10nmol/L Weighted %	Vitamin B_{12} <150pmol/L Weighted %
Age in years (grouped)			
15 - 19	89	31.5	47.7
20 - 49	356	30.6	31.5
Level of education			
Preschool/None	47	36.2	45.8
Primary	253	30.0	37.7
Post primary/ Vocational	127	31.5	26.0
College/ University	18	27.8	27.8
Residence			
Rural	279	25.1	36.9
Urban	165	40.6	30.7
Wealth index quintiles			
Poorest	85	24.7	29.4
Second	98	33.7	39.4
Middle	88	23.9	40.9
Fourth	79	35.4	29.5
Richest	94	36.2	33.0
Total	**445**	**30.9**	**34.7**

Non-pregnant women in urban areas had a higher prevalence of folate deficiency (40.6 percent) than non-pregnant women in rural areas (25.1 percent (Table 9-3).

The national prevalence of Vitamin B_{12} deficiency in non-pregnant women was 34.7 percent, higher than that of pregnant women. There was no significant difference in the distribution of Vitamin B_{12} deficiency in terms of area of residence and wealth quintile. However significant difference was noted in the prevalence of folate deficiency according to age, with the highest prevalence observed in women of 15 – 19 years (47 percent) and lowest in women 20 - 49 years (31.5 percent). Educated women are expected to make better choices in food selection as compared to uneducated or those with low level of education. In this study, significant difference was noted in the distribution of vitamin B_{12} deficiency by level of education. Women who have no education had the highest prevalence of Vitamin B_{12} deficiency (45.8 percent) compared to women with post primary level of education who had the lowest prevalence (26.0 percent) (Table 9-3). The prevalence of vitamin B_{12} decreased with an increase in the level of education.

9.3.1. Folate and B_{12} deficiency in relation to intake among non-pregnant women

There was no significant difference between non-pregnant women with adequate and those with inadequate intake of both folate and vitamin B_{12} in relation to occurrence of folate and B_{12} deficiency (Table 9-4).

Table 9. 4: Folate and Vitamin B_{12} deficiency among non-pregnant women (15– 49 years) in relation to adequacy in RDI of micronutrients

Micronutrients derived from 24hour recall	n	Folate<10 nmol/L unweighted %	Vitamin B_{12} <150 pmol/L unweighted %
Folate			
Inadequate	158	33.5	36.1
Adequate	67	26.9	29.9
Vitamin B_{12}			
Inadequate	195	29.7	34.4
Adequate	30	43.3	33.3

CHAPTER TEN:
FOOD CONSUMPTION PATTERNS, DIETARY PRACTICES NUTRIENT INTAKES

10.1. Infant Feeding Practices

Infant feeding practices for the study population was assessed by asking caregivers /mothers to give details on children's feeding with respect to initiation of breastfeeding after birth, proportions of children under bottle feeding, introduction of complimentary feeding (solid and semi-solid foods) and frequency of all foods consumed by the children including breast feeding.

10.1.1. Breast Feeding

Breastfeeding has well-established short- and long-term benefits, particularly the reduction of morbidity and mortality due to infectious diseases in childhood (WHO, 2013). World Health Organization recommends exclusive breastfeeding for up to 6 months of age, with continued breastfeeding along with appropriate complementary foods up to two years of age or beyond. Our findings show that 95.9 percent of the children aged 6-11 months; 61.9 percent aged 12-23 months; 10.7 percent aged 24-35 and 24.0 percent aged 36-47 months were breastfed the day preceding the survey. The expectation that children be breastfed upto the age of two years was only being achieved by two thirds of the children in that age category.

10.1.2. Early Initiation of Breast-feeding

In this study, mothers and caregivers reported that 93.8 percent of the children were ever breastfed. 33.7 percent of the children were breastfed immediately after delivery, 27.4 percent within an hour, 4.7 percent did not know. Early initiation of breastfeeding is associated with improved immunity for the child due to intake of colostrum. In addition, it is associated with reduced postpartum haemorrhage. WHO recommends that mothers first provide breast milk to their infants within one hour of birth – referred to as "early initiation of breastfeeding". This ensures that the infant receives the colostrum ("first milk"), which is rich in protective factors.

10.2. Micronutrient Supplementation

This section looks at supplementation of vitamin A, iron and folic acid in children and women of reproductive age. Caregivers of mothers were asked to give details of children's supplementation and pica (persistent consumption of non-nutritive substances such as soil or paper) over the last 7 days or six months.

10.2.1. Vitamin A Supplementation in Children 6-59 months

The survey findings indicate that at least 84.3 percent of all the children under five years had ever received vitamin A supplementation while 53.1 percent had received the supplementation 6 months prior to the date of the survey. In settings where vitamin A deficiency is a public health problem, World Health Organization recommends vitamin A supplementation to infants and children 6–59 months of age as a public health intervention to reduce child morbidity and all-cause mortality by 23 percent (Horton et al 2008, WHO, 2011a). According to the World Bank data base, in 2010, vitamin A coverage in Kenya (the percentage of children ages 6-59 months old who received at least two doses of vitamin A in the previous year) was at 62 percent (World Bank-http://data.worldbank.org/indicator/SN.ITK.VITA.ZS) (WHO, 2009). The findings in this survey are much higher than what was reported (30.3 percent) by KDHS 2008 - 2009 but lower than what is reported by World Bank in 2010.

Table 10. 1: Micronutrient supplementation among the Pre School Children

Variables		Percent	n
1.	Has child ever received Vitamin A drops?	84.3	1435
2.	Did the child receive Vitamin A drop within the last six months?	53.1	1210
3.	During last six months were you given/buy any iron tablets, Iron pills, Micronutrient powders, or iron syrups?	4.7	1435
4.	During last six months, were you given or did buy any folic acid tablets?	1.3	1435
5.	Does child eat soil or earth from any source?	29.1	1435
6.	Has child been diagnosed with anaemia in the past 6 months?	2.8	1435
7.	Has child taken any drugs for intestinal worms in the past 6 months	38.3	1435

Among the WRA, in regard to most recent birth, 34.9 percent were supplemented with vitamin A immediately after delivery.

10.2.2. Iron and folic acid use and de-worming in Children

Care givers reported that 4.7 percent of pre-school children and 2.4 percent of school aged children had received or bought iron tables or pills, however, 29.0 percent of the pre-school children and 6.5 percent of school aged children were reported to consume soil or earth. 38.3 percent of preschool children and 33.5 percent school aged children had received medication for intestinal worms while only 2.8 percent were diagnosed with anaemia. Diagnosis will also depend on whether the health facilities have that capacity to diagnose. In the event that there is limited capacity, there is a possibility that a number of cases go undiagnosed. This study did not assess facility capacities and therefore cannot confirm.

10.2.3. Iron Supplementation in Women of Reproductive Age

Daily supplementation with iron and folic acid for a period of three months has been the standard approach for the prevention and treatment of iron deficiency anaemia and prevention of foetal neural tubes defects among women of reproductive age (WHO, 2011b). From the reported information by the respondents only 5.7 percent indicated they were diagnosed with anaemia in the previous six months, 23.5 percent had taken drugs for intestinal worms, 49.7 percent reported that during the time of the pregnancy that occurred in the last twelve months, they bought or received iron supplements. While within the same period 31.6 percent reported having received folic acid. Intermittent use of oral iron supplements (i.e. once, twice or three times a week on non-consecutive days) has been proposed as an effective alternative to daily iron supplementation to prevent anaemia among menstruating women. The proposed rationale behind this intervention is that intestinal cells turn over every 5–6 days and have limited iron absorptive capacity. Thus intermittent provision of iron would expose only the new epithelial cells to this nutrient, which should, in theory, improve the efficiency of absorption. Intermittent supplementation may also reduce oxidative stress and the frequency of other side-effects associated with daily iron supplementation as well as minimize blockage of absorption of other minerals due to the high iron levels in the gut lumen and in the intestinal epithelium (WHO, 2011).

10.3. Dietary diversity

The relevance of food intake in nutrition and health studies is already acknowledged. However, the measurement of food intake needs methods that combine simplicity, validity, and accuracy, which is a challenge given the constraints involved in this task. Food records, 24-hour dietary recall (24hr), and the food frequency questionnaire (FFQ) are the most common dietary assessment methods. Food records and 24hR recalls are based on foods and amounts actually consumed by an individual on one or more specific day (Pereira et al 2010).

Higher dietary diversity has been associated with better nutritional status of children in developing countries (Rah et al., 2010). Dietary diversity ensures adequate nutrient intakes among groups (Ajani, 2010). Dietary problems may be primarily quantitative in the most underprivileged areas, such as rural areas during seasonal food shortages or urban areas under acute poverty. As a result, the nutrient deficiency then appears to be chiefly energy related. However, even in these conditions it has been shown that the problem of dietary diversity is crucial and the measurement of the dietary quality is therefore essential (Savy et al., 2008). As no single food contains all necessary nutrients, diversity in dietary sources is needed to ensure a balanced and healthy diet.

Dietary diversity is most often measured by counting the number of food groups and the selection of foods groups is based on their unique contribution to nutrient adequacy. An individual's dietary diversity score is calculated by summing up the different food groups consumed with a score of 1 assigned for each food group. The food group indicator was based on a total of seven possible food groups: (1) grains, roots and tubers, (2) legumes and nuts, (3) dairy products, (4) flesh foods (meat, fish, poultry, and liver/organ meats), (5) eggs, (6) vitamin A-rich fruits and vegetables (> 130 RAE of vitamin A per 100 g), and (7) other fruits and vegetables, as recommended by the Working Group on IYCF indicators of dietary quality (FANTA 2006; WHO 2008; WHO 2010). For the 24 hr recall data, all food items with a minimum weight of 1 g were included.

The dietary diversity score serves as a useful and simple indicator for assessing quality of diet. Using the number of food groups consumed, a dietary diversity score was calculated for each child, with a range from 0 to 7 (0 if only miscellaneous food items were consumed, 7 if at least one item from all food groups in the index was consumed). Children with a score less than 4 are considered to have inadequate dietary diversity.

Dietary diversity using 24 hr recall data

The grains and tubers food group represents the majority of children's energy intake, on average accounting for 57.4 percent of total energy intake in children 6-59 months of age (Table 10-2). The other food group, which accounted for the second largest proportion of energy intake was dairy products, with an average of 20.1 percent for all children and ranging from 27.3 percent in younger children (6-23 months) to 14.9 percent in older children (24-59 month). Intake of meat, poultry and fish accounted for 8.4 percent of energy intake on average. A comparison of the percent of energy intake by food group for children from rural and urban areas (Table 10-3). Previous studies in developing countries have shown a positive association between dietary diversity and socioeconomic status (Hatloyet. al, 1998) which indicates that the household's capability to acquire necessary foods and the general availability of food, is a prerequisite to achieve the diversification of child diets. For example from figure 10-1 we see that meat based-meals are least consumed by the households in the poorest socio-economic index but the limited protein source appears to be compensated by consumption of more beans and nuts among the poor.

Table 10. 2: Mean percent of energy intake by food group in children 6-59 months overall and by age group 1 (N=264)

	Overall		6-23 month		24-59 month	
Food group	Mean	95% CI	Mean	95% CI	Mean	95% CI
Grains & tubers	57.4	54.3, 60.5	53.9	48.6, 59.3	59.6	55.6, 63.7
Beans, nuts, seeds	8.5	6.4, 10.6	9.3	3.5, 15.0	8.3	6.1, 10.5
Dairy	20.1	16.8	27.3	21.2, 33.4	14.9	12.2, 17.6
Meat, poultry, fish	8.4	6.5, 10.3	9.4	5.4, 13.4	8.1	6.2, 10.0
Eggs	6.5	4.3, 8.7	7.4	3.8, 10.9	5.3	3.3, 7.4
Other fruits & vegetables	7.9	3.6, 12.3	13.1	2.0, 24.2	5.6	2.3, 8.9
Vitamin A-rich fruits & vegetables	8.8	4.9, 12.7	11.1	7.0, 15.1	7.5	1.8, 13.3
Miscellaneous (all other food items)	15.8	13.3, 18.3	15.5	10.2, 20.7	16.1	13.7, 18.4

1 Calculated as the mean of each child's individual intake

Table 10. 3: Mean percent of energy intake by food group in children 6-59 months by area of residence1 (N=264)

	Rural		Urban	
Food group	Mean	95% CI	Mean	95% CI
Grains & tubers	59.7	55.7, 63.7	51.6	46.9, 56.2
Beans, nuts, seeds	9.5	6.8, 12.3	5.7	4.0, 7.4
Dairy	20.7	16.2, 25.2	18.7	15.0, 22.5
Meat, poultry, fish	7.9	5.6, 10.2	9.0	5.9, 12.2
Eggs	9.2	6.1, 12.2	4.2	2.2, 6.1
Other fruits & vegetables	5.5	1.9, 9.1	11.7	2.1, 21.4
Vitamin A-rich fruits & vegetables	9.8	4.3, 15.4	6.8	3.7, 9.9
Miscellaneous (all other food items)	15.7	12.4, 19.0	16.2	13.6, 18.8

1 Calculated as the mean of each child's individual intake

Table 10. 4: Mean number of food groups consumed and proportion with low dietary diversity (DDS<4) among children 6-59 month, by child characteristic (N=279)

Child characteristic	Food Group Index-7		Low DDS (<4)	Risk of low DDS	
	mean (SEM)	95% CI	% (95% CI)	OR (95% CI)	p
ALL	3.63 (0.12)	3.40, 3.87	46.1 (38.0, 54.3)		
Age group					
6-11 mo	2.78 (0.24)	2.30, 3.26	68.8 (53.8, 83.7)	Ref	
12-23 mo	3.95 (0.18)	3.59, 4.30	35.7 (22.0, 49.4)	0.25 (0.10, 0.63)	0.003
24-35 mo	4.09 (0.15)	3.80, 4.38	31.9 (18.8, 45.1)	0.21 (0.09, 0.51)	0.001
36-47 mo	3.35 (0.21)	2.94, 3.76	55.5 (39.8, 71.3)	0.57 (0.22, 1.44)	0.232
48-59 mo	4.41 (0.37)	3.69, 5.13	34.7 (11.2, 58.2)	0.24 (0.07, 0.85)	0.027
Sex					
boys	3.60 (0.14)	3.32, 3.87	45.2 (35.0, 55.4)	Ref	
girls	3.69 (0.19)	3.31, 4.07	47.6 (34.7, 60.4)	1.10 (0.57, 2.10)	0.774
Residence					
rural	3.32 (0.14)	3.05, 3.60	55.9 (45.9, 66.0)	Ref	
urban	4.45 (0.16)	4.15, 4.76	20.1 (10.0, 30.3)	0.20 (0.09, 0.42)	<0.001
Wealth rank					
poorest	2.99 (0.27)	2.47, 3.52	60.6 (43.3, 77.9)	Ref	
second	3.30 (0.17)	2.97, 3.63	57.0 (42.3, 71.8)	0.86 (0.35, 2.14)	0.748
middle	3.82 (0.32)	3.18, 4.46	44.6 (22.1, 67.0)	0.52 (0.17, 1.65)	0.266
fourth	4.02 (0.20)	3.63, 4.42	32.7 (15.7, 49.6)	0.31 (0.11, 0.90)	0.032
richest	4.87 (0.23)	4.42, 5.31	14.6 (2.9, 26.3)	0.11 (0.03, 0.36)	<0.001

Table 10. 5: Description of number of food items consumed per day among children, by age group

Indicator	All Children	6-11 mo	12-23 mo	24-35 mo	36-47 mo	48-59 mo
N	279	62	67	76	49	25
Meals per day, mean (95% CI)	3.08 (2.97, 3.18)	2.86 (2.59, 3.12)	3.22 (2.99, 3.44)	3.19 (3.00, 3.37)	3.10 (2.98, 3.21)	2.99 (2.82, 3.17)
Number of meals per day, %						
1	3.7	9.1	2.0	3.3	0	0
2	9.4	18.1	9.5	6.4	3.0	7.8
3	62.3	50.6	53.5	58.3	84.3	85.0
4	24.6	22.2	35.0	31.9	12.7	7.2

The mean dietary diversity for all children was 3.63 (SEM, 0.12) (Table 10- 4). This is below the recommended cut-off for minimum dietary diversity of at least 4 of the 7 food groups which is associated with better quality for both breastfed and non-breastfed children (FANTA, 2007). The rationale behind this cut-off is that consumption of foods from at least 4 food groups on the previous day would mean that the child has a high likelihood of consuming at least one animal-source food and at least one fruit or vegetable that day, in addition to a staple food (grain, root or tuber) (WHO, 2009).

Children are particularly vulnerable to micronutrient deficiency owing to their high nutrient requirements for growth and susceptibility to infectious diseases such as diarrhoea and respiratory infections, which can inhibit nutrient absorption as well as decrease appetite. The nutrient density of the diet given to young children is often insufficient to meet their nutrient requirements, and increasing the diversity of foods provided to young children, particularly meat, poultry, fish, eggs, fruits and vegetables, is recommended to improve micronutrient intake (Steyn et al ., 2006). About half of all children had a low DDS (46.1 percent). This is an indication that the diets of these children are suboptimal and unlikely to meet their dietary requirements.

Dietary diversity is expected to increase with age. This is the trend we see in our analysis where older children are more likely to consume food from more than 1 food group compared to their younger counterparts. However the numbers per age category were very small to make any meaningful comparisons (Table 10- 4).The youngest age group was at highest risk of low dietary diversity, along with children from rural areas and those from poorer households (Table 10- 4).

Children were reported to consume three meals per day, on average (Table 10- 5).The proportion of children who consumed foods from the standard list of food groups on the observed day is shown in Table 10- 6. Grains, dairy products (primarily milk) and vegetables were consumed in the past 24 hours by a large majority of children. The proportion of children consuming the different food groups generally increased with age, as expected. However, the difference in the proportion of children consuming roots, dairy and eggs was less than 7 percent between the youngest and oldest age groups. The largest increase with age was observed for consumption of meat, fats and sugars (just over 40 percent for each group, not including the miscellaneous group which increased by 48 percent between the youngest and oldest children).A comparison of food group consumption among children by rural/urban residence and household wealth rank is shown in Table 10- 6. More children living in urban areas consumed meat, eggs, fruits, vegetables and fats in the past day compared to children living in rural areas. However, only meat consumption remained independently associated with residence (OR 4.1, 95% CI 1.2, 13.7, p=0.021) after accounting for the household's wealth rank (data not shown).

Table 10. 6: Percentage Intake of food groups among children 5-59 months by different characteristics

	Grains	Roots	Beans	Dairy	Meat	Fish	Eggs	Fruits	Veg	Fats	Sugars	Beverages	Misc
Children 6-59months													
(n=279)	94.3	33.3	26.8	82.7	18.9	9.3	9.4	16.4	74.9	67.6	68.5	44.6	64.9
Age groups													
6-11months (n=62)	84.2	23.4	11.1	80.9	3.5	6.8	7.2	8.0	49.7	39.5	44.8	17.8	33.4
12-59months (n= 217)	97.7	36.6	32.0	83.3	24.0	10.2	10.1	19.2	83.4	77.0	76.4	53.6	75.5
Sex													
Boys (n=	93.7	26.6	29.4	84.7	14.2	7.9	10.0	10.7	75.5	63.0	67.0	48.2	59.2
Girls (n=	95.2	43.2*	22.7	79.6	25.9	11.4	8.5	24.9*	74.8	74.5	70.7	39.4	73.5
Residence													
Rural (n=185)	93.0	30.9	26.8	79.5	10.2	9.4	5.9	12.1	70.2	62.6	66.1	46.3	63.0
Urban (n=94)	97.8	39.6	26.6	91.1*	41.8‡	9.0	18.6*	27.8*	87.4*	81.0*	74.8	40.3	70.0
Wealth Rank													
Poorest (n=75)	90.9	19.8	22.2	70.2	11.0	6.7	8.2	5.5	60.3	51.8	57.1	47.5	59.7
Middle (n=166)	94.9	38.6*	26.6	86.6*	14.0	11.1	6.5	20.1*	78.4	69.2	70.6	46.9	64.0
Richest (n=38)	98.8	38.0	37.1	91.4*	56.4*	7.0	24.7	22.8*	90.2*	93.4*	83.2*	28.6	79.8

* p<0.05 for difference in proportion using logistic regression
‡ p<0.001 for difference in proportion using logistic regression

The average number of meals per day and number of food items consumed by women is shown in Table 10- 7. Women consumed an average of 3 meals per day, with less than 10 percent of women reporting fewer meals per day. Table 10- 8 represents the intake among women of the standard food groups. Consumption of grains was nearly universal. Intake of dairy products, vegetables, fats, sugars and beverages was also very high. Only one quarter of women reported meat intake in the past 24 hours.

Comparison of intake by physiological state reveals that there was lower intake among non-pregnant lactating women. Lactating women were half as likely to consume foods from the meat group (OR 0.5; 0.2, 0.9; p=0.04) and were also less likely to eat fruits (OR 0.4; 0.2, 0.8; p=0.02) and vegetables (OR 0.3; 0.1, 0.8; p=0.02) than NPNL women.

A comparison of intake by women living in different areas and from different household wealth ranks is also shown in Table 10- 8. A higher proportion of women living in urban areas consumed foods from the dairy, meat, eggs, fruits, vegetables, fats and sugars food groups. Even when wealth rank was included in the model, urban women were over four times more likely to eat eggs (OR 4.4; 1.4, 13.7) and fats (OR 4.1; 1.2, 14.0) compared to women living in rural areas. Consumption of dairy, meat, eggs, fruits, vegetables, fats and sugars were associated with a woman's household wealth rank. The higher egg consumption among women from the richest households was explained by her residence and was not independently associated with wealth rank.

Table 10. 7: Number of meals per day and food items consumed among women 15-49 years by age group and physiological status

Indicator	All Women	NPNL	NPNL 15-18 y	NPNL 19-49 y	Pregnant	NP Lactating
N	440	249	19	230	41	150
N meals per day, mean (95% CI)	3.04 (2.97, 3.11)	3.01 (2.95, 3.07)	2.94 (2.81, 3.07)	3.02 (2.96, 3.08)	3.18 (3.00, 3.36)	3.06 (2.90, 3.22)
Number of meals per day, %						
1	1.4	0.7	0	0.8	0.4	2.7
2	6.9	5.4	8.5	5.1	3.8	9.9
3	77.8	86.0	88.7	85.7	73.5	66.0
4	14.0	7.9	2.8	8.5	22.3	21.4

Table 10. 8: Percentage Intake of food groups among women by different characteristics

	Grains	Roots	Beans	Dairy	Meat	Fish	Eggs	Fruits	Veg	Fats	Sugars	Beverages	Misc
Women 15-49years													
(n=440)	99.1	33.0	44.2	84.9	26.1	11.2	13.9	17.1	90.0	88.7	77.9	79.4	90.1
Physiological state													
NPNL (n=249)	98.7	31.7	44.9	88.3	31.0	8.5	16.8	21.2	93.5	91.4	78.9	81.3	89.7
Pregnant (n=41)	100.0	29.1	52.2	81.5	29.4	16.9	5.7	20.9	94.7	91.9	76.1	72.9	88.5
Lactating (n=150)	99.6	36.1	40.9	80.4	17.5*	14.0	11.4	9.7*	83.3*	83.8	76.9	77.9	91.1
Residence													
Rural (n=267)	99.2	32.1	45.8	81.2	19.6	10.9	5.9	13.3	86.9	83.4	72.2	78.4	89.0
Urban (n=173)	99.0	34.5	41.5	90.8*	36.5*	11.8	26.9‡	23.3*	95.1*	97.3‡	87.2*	80.9	92.0
Wealth Rank													
Poorest (n=85)	99.3	21.3	39.8	67.8	17.7	12.9	7.1	5.7	76.6	78.2	64.0	72.0	84.0
Middle (n=283)	98.8	34.5	43.9	87.7*	18.4	11.6	9.8	14.7*	92.5*	89.0*	78.0	81.5	91.2
Richest (n=72)	100.0	40.4	49.4	93.4‡	58.7‡	8.2	33.6‡	36.5‡	95.9‡	98.7‡	91.9‡	80.1	92.9

* p<0.05 for difference in proportion using logistic regression
‡ p<0.001 for difference in proportion using logistic regression

10.4. Nutrient adequacy of women and children using the 24 hour recall

An interactive 24-hr recall multiple pass approach was used to collect one day dietary intake data on all households selected for dietary data collection (Gibson and Ferguson, 2008). Repeat recalls were done on a sub-set of 20 percent of the households on non-consecutive days in order to validate the survey data and to adjust for the variability of consumption between days.

Each woman involved in the study was asked to recall all the dishes, snacks, or other foods she had eaten during this period, regardless of whether the food was consumed inside or outside the household. From a practical point of view, we first let the woman spontaneously describe her food consumption and then we prompted her to be sure that no meal or snacks had been forgotten. Next, a detailed list of all the ingredients of the dishes, snacks, or other foods mentioned, was collected either from the person in charge of their preparation or directly from the woman being interviewed. No distinction was made between recalls made on weekdays or on weekends, insofar

as weekends did not have any special importance in the context of our study.

This report focuses on both macro and micro-nutrients of public health concern. The results presented here are for the diets of children (under the age of five years) and All Women of Reproductive Age (WRA) 15-49 years who include Non-pregnant Women (NPW) and Pregnant Women (PW). Analysis for NPW is further presented categorized into Non-pregnant Non Lactating (NPNL) and Non-pregnant Lactating (NPL) women. These analyses are conducted using PC-SIDE (version 1.0, June 2013). PC-SIDE is a software developed to analyse dietary data. Single 24 hour dietary recalls represent individuals' intakes on single days. Using one 24-hour recall period does not provide an indication of an individual's habitual diet, but it does provide an assessment of the diet at the population level and can be useful to monitor progress or target interventions (FAO, 2011). However, for the assessment of dietary adequacy we need to know the *usual* intake of each nutrient, that is, what the average daily intake would be over many days or weeks. To collect 10 or more days of dietary data is usually not feasible. So PC-SIDE performs a statistical manipulation that, in effect, converts the one day distribution of intakes to the distribution of usual intakes – this is done for each nutrient. To do this analysis, a second day of dietary data is required from at least a sub-sample. The software then removes the *intra-individual variation* (that is, the variation in an individual's intake from day to day) and leaves the inter-individual variation (that is, the variation between the individuals' usual intakes). The resulting distribution can only be analysed or interpreted at the group level.

Adult women would be expected to have energy intakes of around 2000 kcals if they have low levels of physical activity, and around 2500 kcals if they have high levels of physical activity. The average nutrient intakes of children and women, calculated using PC-SIDE, are shown in Tables 10-9; 10-10; 10-11; and 10-12. The NPW 15-49 years in our survey had average (SD) energy intakes of 1944(583) Kcal (Table 10-9). This is slightly below what is expected and could be explained by various factors including some underreporting in the dataset and the drought in the horn of Africa during this period. At the time of data collection, Kenya was in the midst of a severe drought which also affected areas of Ethiopia, Somalia, Djibouti and to a less extent South Sudan, Tanzania, Uganda and Eritrea. The drought affected mainly the arid and semi-arid regions of Kenya. The drought hit Kenya while it was already trying to navigate through economic shocks. The combination of high food and fuel prices may have contributed to reduced ability of the households to access food.The weighted average (SD) energy intakes for children was 12-59months was 1043 (402) Kcals. We did not do a 6-59month weighted average because the younger children (6-11 months) depend heavily on breast milk for their energy needs. Their average (SD) energy intakes was 449(328) Kcals (Table 10-10).

The prevalence of dietary inadequacy of macro and micro-nutrients were determined as the proportion of the population that had usual intakes less than the Estimated Average Requirement (EAR, [Gibson, 2008, WHO and FAO, 2004]) (Appendix 2). Assuming 8 percent bioavailability, the levels of inadequacy for iron were universal (100 percent) for children 6-11months and pregnant women.

10.5. Determinants of variation in energy intake

We tested differences, of energy intake by different independent variables. The factors considered were such as month of interview, enumerator, day of week, residence (urban/rural), wealth quintile, and whether the woman was sick. No differences were found. We then tested a number of interactions, to see if there were any important trends. There were no significant findings. No effect was found on mother's intake by education level. We then tested protein, fat and all the other micronutrients against wealth quintile. The only one which was related to wealth quintile was fat intake. Fat intake was also found to vary by education, and residence. It is likely that the fat

is from expensive animal source food fat or from eating processed junk food and therefore more available for households classified as wealthy using the wealth quintile classification.

Table 10. 9: Average (SD) energy and macronutrients intake among women

	WRA 15-49y				Weighted Averages	
	NPNL 15-18y	NPNL 19-49y	NPL 19-49y	PW 19-49y	All NPW 15-49y	ALL WRA[1]
n individuals	19	232	148	38	399	437
n with 2nd 24hr recall	3	49	25	5	77	82
Energy (kcal)	1842(603)	1881(477)	2055(716)	1871(625)	1,944(583)	1,937(586)
Energy intake / BMR or Req[2]	1.43(0.33)	1.40(0.33)	-	-	0.9(0.44)	0.8(0.42)
Protein (g)	57.5(33.9)	53.6(19.4)	58.3(26.8)	52.5(24.1)	55.5(23.2)	55.3(23.3)
Protein (g / kg body weight)	1.2(0.7)	0.94(0.37)	1.04(0.28)	-	1(0.36)	1(0.34)
Lipid (g)	45.6(34.9)	46.3(16.5)	38.5(15.0)	38.0(14.8)	43(17)	43(17)
% Energy from Fat	22.0(10.2)	21.9(5.6)	16.8(5.5)	18.4(27.4)	20.0(5.8	19.9(9.8)

1 Includes pregnant women

2 Children - Estimated intakes (kcal / kg/ d) by estimated req (requirements) estimated for adequate growth and moderate activity from FAO, 2001. Expected average should be around 1, and it does fall between 0.8 (for the 6-11m who are still being breastfed) and 1.2 (for the 36-47m kids). Women -Estimated intakes (kcal / kg/ d) by estimated BMR (basal metabolic rate, estimated by age and body weight.

Table 10. 10: Average (SD) energy and macronutrients intake among children 6-59 months

	Children 6-59months					Weighted Average
	6-11 m	12-23 m	24-35 m	36 -47m	48-59m	12-59m
n individuals	59	70	83	48	22	223
n with 2nd 24hr recall	10	13	12	10	4	39
Energy (kcal)	449(328)	916(291)	1090(419)	1153(446)	1027(525)	1,043(402)
Energy intake / BMR or Req[1]	0.82(0.64)	1.15(0.37)	1.16(0.40)	1.19(0.48)	0.96(0.52)	1.1(0.42)
Protein (g)	12.7(8.6)	21.8(9.1)	30.2(6.7)	29.4(15.5)	35.8(22.1)	27.9(11.9)
Protein (g / kg body weight)	1.75(1.25)	2.38(1.07)	2.70(0.78)	2.46(1.33)	2.54(0.59)	3(1.00)
Lipid (g)	10.4(7.7)	19.4(9.3)	24.3(17.6)	21.7(7.8)	21.7(11.6)	22(13)
% Energy from Fat	22.3(3.0)	21.1(9.2)	20.1(5.7)	17.0(5.9)	18.5(6.0)	19.6(7.0)

1 Children - Estimated intakes (kcal / kg/ d) by estimated req(requirements) estimated for adequate growth and moderate activity from FAO, 2001. Expected average should be around 1, and it does fall between 0.8 (for the 6-11m who are still being breastfed) and 1.2 (for the 36-47m kids). Women -Estimated intakes (kcal / kg/ d) by estimated BMR (basal metabolic rate, estimated by age and body weight.

Table 10. 11: Average (SD) micronutrients intake among women

	WRA 15-49y					Weighted Averages
	NPNL 15-18y	NPNL 19-49y	NPL19-49y	PW 19-49y	All NPW 15-49y	ALL WRA[1]
n individuals	19	232	148	38	399	437
n with 2nd 24hr recall	3	49	25	5	77	82
Calcium (mg)	510(174)	587(225)	599(390)	511(281)	588(295)	581(294)
Iron (mg)	12.6(2.9)	12.0(2.9)	13.38(1.81)	11.8(4.8)	12.6(2.6)	12.5(2.8)
Zinc (mg)	7.5(3.3)	8.1(2.7)	8.31(3.68)	9.2(3.4)	8.1(3.1)	8.2(3.1)
Vitamin A (mcg)	577(957)	750(460)	847(284)	734(485)	778(442)	774(445)
Folate (mcg)	320(138)	275(88)	251(129)	263(194)	268(107)	268(117)
Vitamin B_{12} (mcg)	1.98(0.93)	2.41(1.98)	2.65(0.81)	3.68(8.72)	2.5(1.6)	2.6(3.0)

1 Includes pregnant women

Table 10. 12: Average (SD) micronutrients among children 6-59 months

	Children 6-59months					Weighted Average
	6-11 m	12-23 m	24-35 m	36 -47m	48-59m	12-59m
n individuals	59	70	83	48	22	223
n with 2nd 24hr recall	10	13	12	10	4	39
Calcium (mg)	226(197)	361(209)	406(224)	365(362)	478(625)	390(313)
Iron(mg)	2.3(2.4)	4.2(2.4)	6.6(3.1)	9.2(6.6)	8.7(9)	6.6(4.8)
Zinc (mg)	2.1(1.8)	3.6(3.4)	4.8(0.5)	4.8(2.8)	4.9(2.6)	4.4(2.4)
Vitamin A (mcg)	156(189)	326(272)	323(403)	284(255)	376(353)	321(332)
Folate (mcg)	45(54)	91(50)	91(71)	147(103)	161(99)	110(77)
Vitamin B_{12} (mcg)	0.73(0.75)	1.13(1.02)	2.04(3.58)	0.70(0.95)	1.33(0.80)	1.4(2.3)

Table 10.13: Prevalence of dietary inadequacy of macro and micro-nutrients among women and children

	Children 6-59 months						WRA 15-49y					
	6-11 m	12-23 m	24-35 m	36 -47m	48-59m	12-59m	NPNL 15-18y	NPNL 19-49y	NPL 19-49y	PW 19-49y	NPW 15-49y	ALL WRA[1]
n individuals	**59**	**70**	**83**	**48**	**22**	**223**	**19**	**232**	**148**	**38**	**399**	**437**
n with 2nd 24hr recall	**10**	**13**	**12**	**10**	**4**	**39**	**3**	**49**	**25**	**5**	**77**	**82**
		%	%	%	%	%	%	%	%	%	%	%
Calcium		76	73	76	85	76	100	85	79	85	84	84
Iron*	100%	86	60	47	71	67	89	91	77	100	86	87
Zinc	66%	33	0	11	45	17	5	34	78	60	49	50
Vitamin A		40	52	50	50	48	4	33	62	43	43	43
Folate		78	76	48	58	69	52	73	92	91	79	80
Vitamin B_{12}		42	35	66	40	44	59	52	42	68	48	50
% Energy from fat		84	95	98	87	91	71	39	74	63	54	54

* assuming 8% bioavailability. Assuming 18% bioavailability, the prevalence of dietary inadequacy among NPW is 26% while that among WRA is 32%

10.6. Relationship of dietary and biochemical data

Dietary data intake was collected from a sub sample of the pre-school children and non-pregnant women of reproductive age. Arising from that, a comparison has been made between dietary data and biochemical data in the subsample that had both datasets available. As such, therefore the prevalence will not be similar to what is presented in the chapter 5. We did not expect perfect concordance between the dietary and biochemical data. However, we looked at this relationship to estimate specifically the prevalence of dietary iron inadequacy and prevalence of iron deficiency with the assumption that estimated dietary iron requirements are set at levels intended to prevent an insufficient supply of iron to tissues, and if not met will contribute to iron deficiency and anaemia. From our data, about 100 percent of children 6-11months and 67 percent of all children 12-59months and 87 percent of all WRA[7] (32 percent of all WRA recruited in the survey)[8] have insufficient dietary iron to meet their needs while about 15.9 percent and 30.7 percent of the children and about 26.0 percent and 24.4 percent women are iron deficient (using appropriate cutoffs for SF and sTfR respectively). The trend between the younger age groups and pregnant women are very similar with non-pregnant women being the most iron inadequate or iron deficient using both categorizations.

10.7. Dietary sources of micronutrients

The first day 24 hour recall data was used to analyse the dietary sources of micronutrients. The sum of four micronutrients (iron, zinc, calcium, vitamin A), as well as energy and lipid, from 11 different food groups (beans, nuts and seeds; beverages; eggs; fats and oils; fruits and fresh/pure fruit juices; grains and grain products; meats, poultry and insects; milk and dairy; sugars and sweets; vegetables; miscellaneous) were divided by the daily total from all food groups to determine the percentage contribution from each food group. Grains are the leading source of dietary energy (Appendix 3a), and milk and dairy are also important sources in children. Other animal source foods (eggs, meat and insects) contribute less than 5 percent. Grains are also an important source of lipids (Appendix 3b) but fats and oils, and milk and dairy contribute more. Grains are, in fact, important sources of all the micronutrients studied (Appendix 3c-3e) except for vitamin A. Grains are the leading source of iron and zinc, milk and dairy is the leading source of calcium, and vegetables are the leading source of vitamin A.

10.8. Appropriate food fortification vehicles

It was also the objective of this survey to identify foods ideal for food fortification. Food fortification is an effective means of increasing micronutrient intake at relatively low cost, and is practiced with many foods in many countries. Kenya currently has ongoing or planned fortification of salt, wheat flour, vegetable oil and maize meal, but there is scope for improvement of their fortification program. The data from the 24 hour dietary recall are a source of information to identify suitable fortification vehicles. Suitable vehicles have certain production and distribution characteristics (e.g., fortification with needed micronutrients is technically feasible, the production and distribution of the food is relatively centralized), but these cannot be assessed with dietary recall data. With the recall data, assessment of two key characteristics is possible.

1. Regularity of consumption: The food to be fortified needs to be consumed regularly (daily) by a high percentage of the target population;
2. Range of consumption levels: Ideally, the usual distribution of intakes is relatively narrow, so that fortification levels can be

7 Assuming 8% bioavailability
8 Assuming 18% bioavailability

set that will be sufficient for the low-end consumer, but not excessive for the high end consumer.

In this chapter the foods we considered from the dietary data were: Maize Flour, Wheat Flour, Sugar, Oil, Salt, Wheat flour products, Vegetable Fats, Royco® Cubes, Powder Milk, Tea, and Milk. The first five foods (the flours, sugar, oil and salt) are also considered in the next chapter which compares the intake estimates from the 24 hour recall data to the estimates from household usage questions, to determine if the two types of questions yield similar information for use in fortification program monitoring. The list of specific food items included in each of the foods tested are listed in Appendix 4. Even a food as apparently standard or homogenous as table salt was recorded as 11 separate, specific food items. These foods are all combined into a single "food" without regards to the individual differences (e.g. salt includes non-iodized salt, iodized salt, and sea salt).

For each food, the average, standard deviation and median of consumption (grams per day) and the percent of individuals who consumed the food on one observed day are calculated. Subgroup analyses are somewhat limited by small sample-sizes but nonetheless they were carried out and presented by area of residence (rural or urban) and by wealth quintile (only the first, third and fifth quintiles are shown).

10.9. Maize and wheat flour, sugar, oil, salt, cow's milk

The findings indicate that maize flour, sugar, salt and cow's milk were widely consumed. Maize appeared in the recall data of more than 80 percent of most age groups and in amounts proportionate to age compared to wheat flour which was less widely consumed, appearing in the recall data of at most 31 percent of individuals in any age groups, and amounts were not directly proportionate to age (older children had similar intakes to younger adults). There are minor differences between urban and rural consumers and there were slightly fewer maize flour than wheat flour consumers in the highest wealth quintile. Wheat flour was consumed on more days in urban areas than rural areas. However, almost 50 percent of older children and women had wheat flour on at least one day. The variation in wheat flour intake per day was even larger than for maize flour, with the standard deviation being more than double the mean in most age groups. For those with repeat observations only about 10 percent did not consume maize flour on at least one day. The first and second day amounts were correlated in consumers[9]. The variation in maize flour intake per day was large, with the standard deviation being close to the mean in most age groups.

Sugar and salt were both widely consumed. Sugar appeared in more than 70 percent of the days and in amounts roughly proportionate to age. Salt was consumed by about 90 percent of adults, and two-thirds of children and the amounts were greater in adults than children. Salt consumption appears similar between urban and rural areas compared to sugar where urban individuals consumed more sugar than rural. The consumers in the poorest wealth quintile consumed less sugar, but still more than 60 percent took sugar. For those with repeat observations about 20 percent did not consume sugar on at least one day. The first and second day amounts were highly correlated in consumers. The standard deviation was approximately equal to the mean in most age groups. While there were some differences by wealth quintile in salt consumption, it was high (>70 percent) in almost all groups.

Cow's milk was consumed by more than two-thirds of all age groups, with amounts greater than 200 grams per day in most age groups.

9 Note that a correlation between days is not necessarily desirable. If the correlation is truly 0, then over the long term, individual intakes would equal the group average intake. Fortification decisions can be made based on the average daily intake (which is an easier quantity to measure through surveys) and not be concerned about possible excessive intakes in the high end consumers.

However, the percentage of milk consumers in urban areas is much higher than rural, and much higher in individuals in the wealthiest quintile. The poorest quintile has about two-thirds as many consumers as the wealthiest quintile. Most of the individuals who consumed milk on the first day of observation also consumed it on the second day, and the amounts consumed on the two days were correlated.

Milk could be a suitable food for fortification. It is consumed in higher amounts in wealthier households, but it would still reach at least half of the poorest individuals.

Summary

The consumption levels of twelve foods were evaluated for suitability for fortification. Five foods (wheat flour products, vegetable fats, Royco® cubes, powder milk, and tea) were dismissed from consideration because of low consumption levels. Seven other foods were evaluated in more detail, summarized in Table 10- 14. Maize flour and salt are excellent candidates for fortification. Sugar could be a good candidate, but, if fortified, care would be needed in implementation and promotion, as it would be unwise to promote greater consumption of sugar due to other health risks of excessive sugar consumption. Cow's milk has the consumption pattern that would be suitable for fortification, but since most of the cow's milk in rural areas is consumed unprocessed, it would be difficult to incorporate milk in to a large scale, centralized, fortification program. Overall, higher consumption of the selected foods is seen in populations with highest wealth quintile.

10.10. Validation of HCES as a tool for monitoring food fortification programs

While food fortification can be an effective means of increasing micronutrient intake at relatively low cost, it is relatively difficult to identify suitable foods for fortification ("vehicles") and to monitor the consumption of the vehicle. Conducting regular 24 hour dietary recalls is prohibitively expensive and so alternative methods are being sought and tested. One idea has to been to use "Household Consumption and Expenditure Surveys" (HCES) which are routinely collected in many countries and which measure the purchase of foods, among other things (Lividini *et al.*, 2013).

Within the KNMS, data were collected on the purchase of five foods – maize flour, wheat flour, sugar, salt and oil/fat – which would be similar to the data that are collected in HCES. This allows for the direct comparison of the data collected with 24 hour recalls and with HCES-like questions to see if HCES data are valid at estimating individual

Table 10. 14: Of consumption levels of food candidates for fortification

	Consumed by at least:				
Food	Two-thirds of all adults and children[1]	Half of rural residents	Half of lowest wealth quintile	% women who consumed on at least 1 day	Recommended for fortification?
Maize Flour	Yes	Yes	Yes	87%	Yes
Wheat Flour	No	No	No	47%	No
Sugar	Yes	Yes	Yes	80%	Maybe
Oil	No	No	No	69%	No
Salt	Yes	Yes	Yes	92%	Yes
Cow's Milk	Yes	Yes	Yes	83%	Maybe

1 Not including children 0 to 1 years.

intakes of the fortified foods. For each of the five foods, the respondent was asked how many grams or kilograms of the food the household used per month or per day (salt was somewhat different – see below). They were asked to respond in one of four different categories, and the midpoint of these categories was used as an estimate to calculate the daily household consumption of the food – see Table 10-15.

With salt, the households were asked the quantity of salt they usually purchase, and the frequency of purchase. The range of responses is shown in Table 10- 16. The frequency was divided by the estimated number of days between purchase to estimate the daily usage, show in Table 10-17.

Table 10. 15: Questions asked in household survey about quantity of consumption of maize flour, wheat flour, sugar and oil, the categories of answers for each food, and the amount used for each category in calculation of daily intakes. The final column shows the percent

	MAIZE FLOUR			WHEAT FLOUR		
	How many Kg of maize flour does your family use daily? (on an average)			How many Kg of wheat flour does your family use daily? (on an average)		
Response Category	Range on Questionnaire (kg/day)	Used in Calculation	% HH in category	Range on Questionnaire (kg/month)	Used in Calculation	% HH in category
0	< 1 kg	500g	35	< 0.5 kg	250 g	4
1	1 to <2 kg	1500g	42	0.5 to < 1 kg	750 g	9
2	2 to <3 kg	2500g	12	1 to <2 kg	1500 g	16
3	3 to <4 kg	3500g	4	2 to < 3 kg	2500g	13
4	4+ kg	4500g	2	3+ kg	3500g	25
missing	.	0	5	.	0	33

	SUGAR			OIL/FAT		
	How many grams of sugar does your household consume monthly?			How many grams of oil/fat does your family use daily? (on average)		
Response Category	Range on Questionnaire (g/ month)	Used in Calculation	% HH in category	Range on Questionnaire (g per day)	Used in Calculation	% HH in category
0	< 0.25 kg	125	1	< 10 g	5	17
1	0.25to<0.5kg	375	3	20 - 30 g	25	44
2	0.5 to < 1 kg	750	6	30 - 50 g	40	22
3	1 to < 2 kg	1500	20	50 - 100 g	75	7
4	2+ kg	2500	57	50 - 100 g	150	6
missing	.	0	13	.	0	4

Table 10. 16: Quantity of salt usually purchased, and frequency of salt purchase in households

SALT QUANTITY			
Response Category	**Range on Questionnaire (g per day)**	**Used in Calculation**	**% HH in category**
1	< 100 g	50	3.2
2	100 to 250 g	175	27.0
3	250 g to 500 g	375	32.8
4	500 g to 1 kg	750	19.3
5	1+ kg	1250	14.8
missing	.	0	2.9

SALT PURCHASE FREQUENCY			
Response Category	**Range on Questionnaire (g per day)**	**Divide quantity by this to get daily use**	**% HH in category**
0	< once a month	15	41.6
1	once a month	30	39.2
2	once in 2 to < 3 months	75	14.9
3	once in 4 to < 6 months	150	2.5
7	other	na	1.8
missing	.	0	n=90

Table 10. 17: Estimated consumption of salt per day

Calculated amount (g) used per day per HH	% HH in each category
0.0	3.8
0.7	0.2
1.2	0.3
1.7	1.0
2.3	1.6
2.5	0.5
3.3	2.1
5.0	3.8
5.8	7.9
8.3	1.3
10.0	3.8
11.7	16.7
12.5	13.1
16.7	5.7
25.0	25.4
41.7	6.5
50.0	5.0
83.3	1.5
missing	n=42

Comparison of HCES and 24 hour recall estimates

There are a number of parameters of food consumption that an ideal food fortification monitoring tool would be able to measure accurately. These parameters are listed in Table 10- 18 and the ability of 24 hour dietary recalls and HCES to estimate those parameters are described. Also, the expectations of a comparison of each tools' estimates for each of the parameters is described in the right-most column.

Table 10. 18: Five parameters that an ideal monitoring tool could measure, the ability of 24 hour dietary recalls and HCES to measure these parameters, and the meaning of this for tool validation

Parameter	24 hour recall	HCES	Expectations of the comparison of 24 hour recall and HCES for the purposes of tool validation.
Average daily intake of food by different age groups	The average can be estimated.	The average can be estimated, but distribution within household is assumed to be proportionate to energy requirements.	If both tools are accurate, then the averages should be the same.
Variation in usual daily intake (not variation on a single day)	With single day of data the variation in usual intake would be overestimated, because it includes intra-individual (between day) variation.	Yes, variation in usual intake is estimated, because intra-individual (between day) variation is zero, due to the nature of the tool.	Since a single 24 hour recall includes both intra- and inter-individual variation, and the HCES only includes inter-individual variation, the variation in the HCES should be larger.
Maximum one day intakes by individuals in each age group	While the true maximum cannot be accurately estimated, a high percentile (e.g. 95th percentile) can be reasonably estimated	Without knowing the intra-household distribution of the food, the maximum cannot be reasonably estimated. Crude assumptions (e.g. all the food purchased by household eaten by one person) could be carried out, but are not of practical value.	A comparison would not be meaningful.
Percentage of individuals who never consume food	The percentage cannot be estimated from a single or few days of data. Individuals who do not eat a food on the observed day may eat it on subsequent days.	It is assumed that intra-household distribution is proportionate to requirements, and therefore it is assumed that if the household uses the food all individuals are consumers. However, if the household does not purchase or use the food, then it is reasonable to assume that all individuals in the household are non-consumers.	The estimates of non-consumers with both tools are highly error prone. The 24 hour recall would overestimate and the HCES would under-estimate non-consumers. The two methods together may provide high and low limits around the true rate of non-consumption, but a comparison of the results yielded by the two methods would not be meaningful for tool validation.
Intra-household distribution	The distribution can be estimated	The real intra-household distribution is not measured. Estimating the distribution is simply describing the variation in energy requirements within the household.	A comparison would not be meaningful.

Considering these points, we now compare the 24 hour recall data and the HCES in their estimates of average intakes, and variation in intakes, for maize flour, wheat flour, sugar, oil and salt.

Maize flour

While the HCES provides an estimate for every member of the household (indeed it is necessary to estimate the intake of every household member so that the food purchased by the house is proportionately distributed), the 24 hour dietary recall provided estimates for only children and adult women. The HCES estimated intakes of approximately double the 24 hour recalls.

The calculations were also done by residence (rural and urban) and by wealth quintile. The relative differences are calculated as the ratio of intake estimates in grams per day for HCES divided by the estimates for 24 hour recalls (Relative difference = (HCES / 24 hr). Clearly for all age groups and all subgroups, the HCES estimates higher intakes than the 24 hour recall, by only a small amount for the poorest quintile adults, to four times or more for the highest quintile children. Note that the biggest relative difference is for the youngest children. Dietary intakes are notoriously difficult to measure in young children. However, even in the older groups the difference is still usually more than two-fold. R ecall in Chapter 6 where it was demonstrated that dietary intakes were usually underreported

in the 24 hour recall by some unknown amount. When these findings are re-calculated assuming that the 24 hour recall data were underestimated by one-third (that is, the 24 hour recall estimated intakes were multiplied by 1.5). While this brings the two estimates closer together, they are still farther apart to use the two tools interchangeably to estimate maize flour intake.

While the estimates of absolute intake are significantly different, the tools ranked the age groups similarly with most rankings from highest to lowest being identical between the two tools, or off by a rank of 1 or 2.

Finally, the standard deviation (SD) in maize flour intakes generated using the two methods were compared. Interestingly, and unexpectedly, the methods generated SDs that were relatively similar. The SDs of the tools represents different parameters. For the HCES it is the SD of *usual* intake, which should be relatively narrow. For the 24 hour recalls, it is the SD of *one day* intakes, which should be relatively broad. But for the entire sample, and even more so for rural populations and the poorest wealth quintile, the SDs are within 20 percent of each other. This may simply be a function of the high (over) estimates of the HCES leading to inflated SDs, and the low (under) estimates of the 24 hour recall averages leading to depressed SDs, which somewhat balances out the inherent differences that come from being variation in usual (for HCES) or one day (for 24 hour recall) intake estimates.

Salt

The average intakes of salt for the different age groups are shown in Figure 10- 1. Unlike with wheat flour, the HCES did not always estimate greater intakes than the 24 hour recalls. With the exception of the adolescent females, the two tools match estimates quite closely.

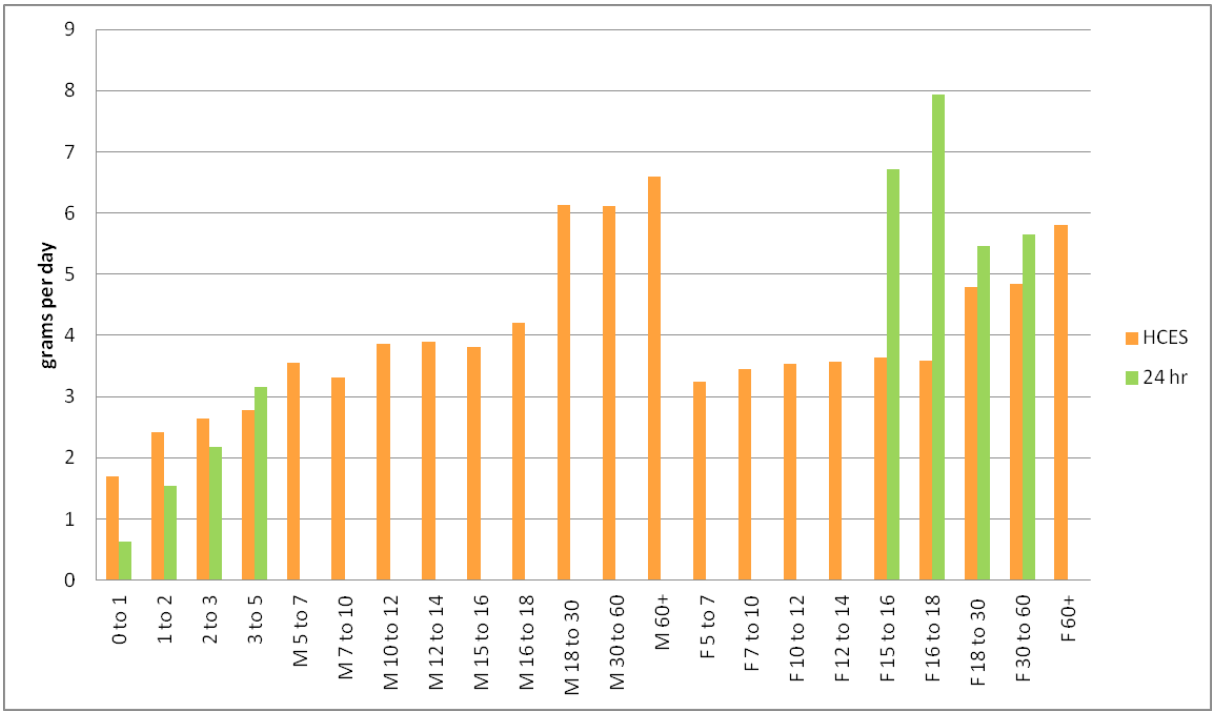


Figure 10. 1: The intake of salt (grams per day) as estimated by the HCES-like questions in the household survey and by the 24 hour dietary recalls for different age groups (age boundaries of group shown in horizontal axis labels, M is for males and F for females).

The calculations were also done by residence (rural and urban) and by wealth quintile. The relative differences are also, calculated as the ratio of salt intake estimates in grams per day for HCES divided by the estimates for 24 hour recalls (Relative difference = (HCES / 24 hr).

In most of the subgroups, the HCES estimates higher intakes than the 24 hour recall in the children, but lower intakes in adults. With the exception of the youngest children (and recall that dietary intakes are difficult to measure in young children) the tools estimates are within 50 percent of each other.

Wheat Flour, Sugar, and Oil

For the other three foods with HCES-like data, wheat flour, sugar and oil, the recommendation (Section 8.8) is not to consider them as suitable fortification vehicles. Therefore the similarity between HCES and 24 hour recall estimates of intakes are presented only for the entire sample in Figures 10-2 a, b and c where higher estimates through 24 hour recall are shown in almost all cases (sub sample analyses, not presented, show a similar trend). For wheat flour and sugar, the 24 hour intake estimates are approximately double the HCES estimates. The oil estimates are similar to the salt estimates, where the estimates are within 50 percent of each other.

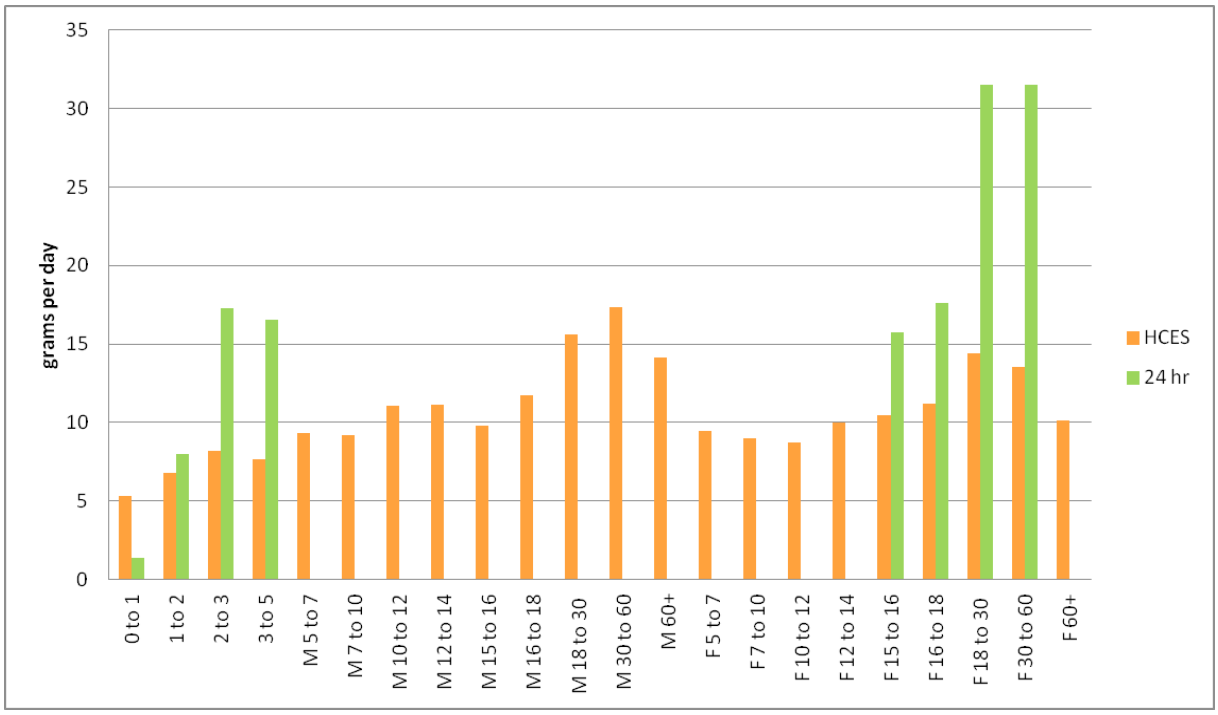


Figure 10. 2a: The intake of wheat flour (grams per day) as estimated by the HCES-like questions in the household survey and by the 24 hour dietary recalls for different age groups (age boundaries of group shown in horizontal axis labels, M is for males and F for females).

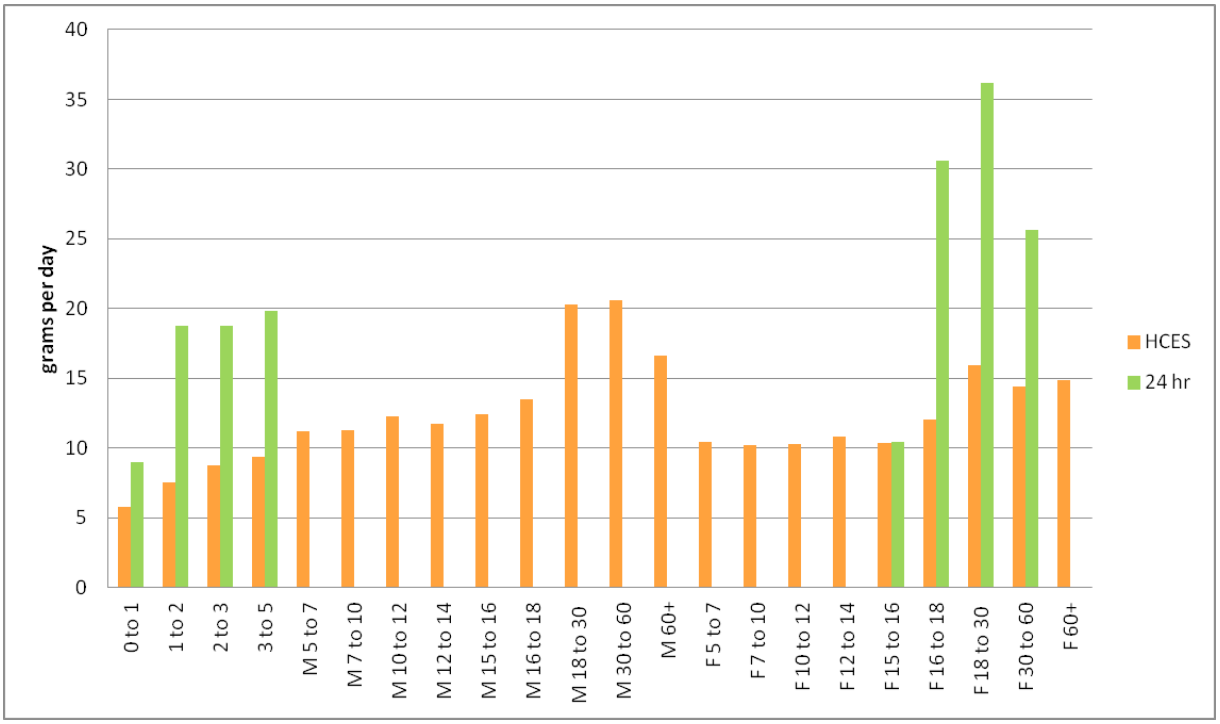


Figure 10. 2b: The intake of sugar (grams per day) as estimated by the HCES-like questions in the household survey and by the 24 hour dietary recalls for different age groups (age boundaries of group shown in horizontal axis labels, M is for males and F for females).

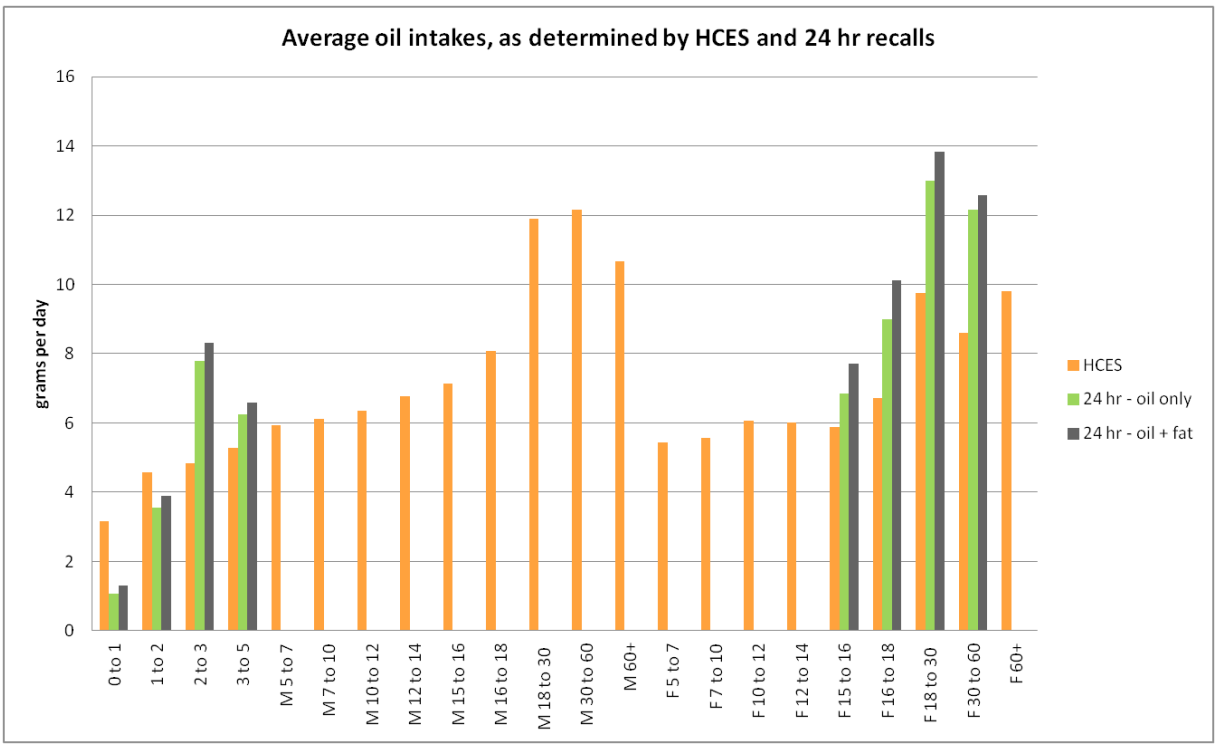


Figure 10. 2c The intake of oil (grams per day) as estimated by the HCES-like questions in the household survey and by the 24 hour dietary recalls for different age groups (age boundaries of group shown in horizontal axis labels, M is for males and F for females). In the case of oil, the 24 hour recall intakes are calculated for oil only, and oil plus vegetable fat.

Table 10. 19: Summary of the comparisons between the intake estimates from HCES and 24 hour dietary recall for maize flour, salt, wheat flour, sugar and oil.

Food	Estimates[1] within 50%?	Tool yielding higher estimate	Units of question[2]	Scale of answer	
				In possible responses on q'airre	in calculated g/d
Maize flour	No	HCES	kg / day	kg	Hundreds
Salt	Yes	na	g / day	g	Ones
Wheat flour	No	24 hour	kg / day	kg	Tens
Sugar	No	24 hour	g / month	kg	Tens
Oil/Fat	Yes	na	g / day	g to kg	Ones to Tens

1 For purposes here consider only the older children (2 to 3 and 3 to 5 years) and older adults (18 to 30 and 30 to 60 years). The diets of younger children are very difficult to assess, and the younger adults had a small sample size.

2 The units used when conducting the questionnaire, for example "How many Kg of maize flour does your family use daily? (on an average)".

CHAPTER ELEVEN: CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

Nationally, malnutrition remains a problem. According to WHO classification of severity of malnutrition among children under five, stunting wasting and underweight reported in this survey are classified at medium level of severity. These results together with the recent results from the KDHS 2014 show that Kenya met the Millennium development Goal for underweight of 11 percent. However, MDG target for wasting and stunting were not met. The stunting, underweight and wasting pattern of malnutrition identified the male children at higher risk of malnutrition. Among non-pregnant women, the average BMI was within normal (18.5-24.9) and was higher in urban non-pregnant women compared to their rural counterparts. Obesity (BMI>30) was higher in urban non-pregnant women. Mean BMI was higher in men living in urban areas compared to the rural male population. There was little variability between the thinness of pregnant women residing in rural areas compared to those in urban areas.

According to the World Health Organization (WHO) classification, anaemia in pregnant women is of severe public health significance, while in preschool children and non pregnant women anaemia is of moderate public health significance. In school age children and men, anaemia is of mild public health significance. There is a significant reduction in anaemia prevalence in all the age groups from the previous national micronutrient survey conducted in 1999. In preschool and school age children, there has been a significant reduction in anaemia as noted in Kenya Malaria Indicator Survey of 2010 to 2011 Kenya National Micronutrient Survey.

Factors found to have an effect on anaemia in preschool children include age, where young children were found to be more affected than older children, low wealth quintile, low level of education of household head, and in-adequate intake of iron. Residence is an important factor for anaemia in school age children, pregnant women and non pregnant women. Rural residence was found to be a risk factor for anaemia in all these age groups. Living in low wealth quintile households and households with household heads of levels of education is a risk factor to anaemia in school age children. Anaemia among non-pregnant women is associated with old age, low level of education and presence of thalassaemia.

Vitamin A deficiency was highest among preschool children (PSC) than in school age children (SAC). In SAC, the main factors associated with VAD were age, level of education, and wealth while area of residence and sex did not have a significant different in this age group. Among pregnant women, VAD (including marginal) was higher in those residing in urban areas. Age and residence were significantly associated with VAD among non-pregnant women. VAD in men was almost non-existent. Based on the 2011 KNMS, VAD is a problem of mild public health concern in Kenya.

The findings from this survey clearly indicate that more than half of the salts found in households was not adequately iodized going by the Kenyan standard (30-50 ppm) of iodized salt at the household. All the major salts in the market or as found at the households indicate that the population is exposed to both inadequately and overly iodized salts. The distribution of these salt brands is in equal measures in rural and urban areas. It is also noted that a considerable population 25.2 percent of the population has presentation of iodine deficiency going by the urinary Iodine levels in this survey. The pattern of iodine deficiency is similar in both school age children and non-pregnant women. The prevalence of the

deficiencies is similar in children (22.1 percent) and non-pregnant women (25.6 percent). In both populations, the deficiencies are higher in the rural areas than in urban areas. However it's important to note that the deficiencies are high in female children. This pattern presents a uniform distribution of the challenges in school age children and non-pregnant women that need to be addressed.

Within the context of the findings of this survey, the prevalence of zinc deficiency across all the groups suggest a higher zinc deficiency than in 1999. In 1999, approximately half of the children, women and men (50%, 52% and 46% respectively) had serum zinc levels below 65 µg/dL (Mwaniki *et al*, 1999). This high prevalence of zinc deficiency is way above the 20% prevalence cut-off to raise a public health concern. These findings are very similar to those reported in Cameroon in 2014 where 82% of the women and and 83% of children aged 12-59 months respectively had low adjusted plasma zinc concentration (Engle-Stone et al, 2014). The results suggest that a concerted effort is needed in the country to improve the zinc nutrition. Due to the sensitive nature of plasma zinc measurement, it may be important to conduct smaller validation studies to inform policy and programming around zinc interventions.

The folate and B_{12} results from the KNMS are the first nationally representative data for both folate and B_{12} deficiencies in Kenya. Prevalence of folate deficiency in pregnant and non pregnant women was found to be almost the same. This compared closely with studies done in India and Venezuela. The prevalence of B_{12} deficiency was found to be different between pregnant and non pregnant women. Generally the prevalence of vitamin B_{12} deficiency is much low than that reported in India and Venezuela. Urban residence was found to be associated with folate deficiency in non pregnant women. Young age and low level of education were also found to be associated with folate deficiency in non pregnant women.

This study had a component to validate the use of HCES as a tool for monitoring the intake of food fortification vehicles. However, the results are too inconsistent to draw a firm conclusion. Two of the five foods had relatively similar estimates, two of the foods had higher estimates from the 24 hour recalls and maize flour had higher estimates from the HCES. The units of the questions were different between the foods, with a mix of grams and kg, and per day and per month. The two foods with the most similar estimates, salt and oil/fat, were those foods consumed in the smallest amounts. The reason for this is unclear. Perhaps the respondents were better able to judge the amounts that they used when they were small amounts – such as teaspoons of salt or oil added to the pot, rather than the large handfuls or ladles in the case of the flours. Or perhaps the containers that the salt and oil come in have clearly marked quantities, and the flours do not – or some other such reason. This is mere speculation and qualitative research would be required to determine the real reason for the differences between the estimates for the different foods. In conclusion, with this analysis the HCES has not been validated and it is difficult to conclude that the HCES is not necessarily less valid than the 24 hour recall given that typically we know that 24 hr recalls have been associated with underestimation of food intakes.

11.2 Recommendations

Stunting, a chronic form of malnutrition, has multiple causes. Concerted multi-sectoral effort will be required to meet WHA targets though the country has been on course to meet the targets. Kenya is also facing double burden of malnutrition as observed in this survey. Over-nutrition is a risk factor for non-communicable diseases which lead to high health care costs and poor quality of life. There is need to come up with workable strategies to address over nutrition especially in the urban areas where higher prevalence of over nutrition has been observed. There is need for enhanced implementation and scaling up of prevention and control strategies for obesity and associated comorbidities in Kenya.

The KNMS 2011 has revealed the importance of anaemia and the progress made in the reduction of anaemia prevalence in Kenya. The role of

factors other than iron deficiency in development of anaemia has been underestimated in the past, largely because anaemia has, for a long time, been confused with iron deficiency anaemia. This has influenced the development of strategies and programmes designed to control anaemia, with less emphasis paid on control and prevention of iron deficiency, a major cause of anaemia. Building on to the successes achieved so far, attention should now be directed to addressing all causes of anaemia and implementing them to scale. The priority target population is pregnant women who were the most affected followed by preschool children and non pregnant women. Attention to the social determinants of anaemia is necessary. Looking at the findings of VAD, it may be useful to the population for government to intensify available intervention to continuously prevent VAD and reverse the marginal VAD levels to normal.

There is a need to be concerned about the 25.6 percent of the population that had mild and moderate iodine deficiency. At this point it's important to note that based on previous studies done on iodine in early years spanning from 1965, 1978, 1989 seem to point deficiency of iodine in the same regions in the country as found in this survey. This is an indication of concerns that need further interrogation. The survey findings showed wide ranges in iodized salt across different brands. The recommendation for more effort in getting salt producers to adequately iodize salt has been addressed by ministry of health with support from partners, a process that is ongoing. Regional assessments are urgently needed to identify endemic areas of iodine deficiencies to identify causes. Since there is knowledge that cruciferous vegetables like cabbage, kale, cauliflower, broccoli, turnips, and rapeseed contain glucosinolates compete with iodine for uptake by the thyroid, further studies are needed to identify if these foods have a role in thyroid deficiencies in certain regions.

Importance of folate in pregnant women cannot be re-emphasised in prevention neural tubal defects. For it to be effective, the body stores should be adequate before and in the early stages of pregnancy. The reason being, neural tubal defect occur within the first 28 days of pregnancy. B_{12} together with folate is important in prevention of megaloblastic anaemia. The high prevalence of low serum zinc concentrations in this report compared to the 1999 National Survey is still indicative of the need for concerted efforts in addressing the problem of zinc deficiency in Kenya.

High salt and sugar consumption in the population calls for urgent public health actions and policy actions to mitigate this trend amid the knowledge that high consumption of salt and sugar is one of the contributon factors for increased non communicable diseases. There is a need for programmatic interventions to reverse the trends.

It is recognized the Ministry of Health has commited itself to improve the nutrition situation in Kenya as defined in National Nutrtion Action Plan 2012-2017. However together with partners in the sector there is need to scale up high impact nutrition interventions with a focus on micronutrients. Diferent approaches should be employed. These include;

1. Continued promotion of exclusive breastfeeding and implementation of the Breast Milk Substitute act. This has been the gold standard in promotion of optimal growth, prevention and management of magement of malnutrition.
2. Food based interventions such as diet diversifications and modification. This may be addressed together with other nutrition sensitive intervention under agriculture sector such as promotion of kitchen gardens and promotion of locally available underutized foods.

3. Promotion and scaling up fortification of staples with micronutrients such as iron and zinc. As well as promotion and scaling up home fortification especially among children 6-23 months using multiple micronutrient powders.
4. Scale up of micronutrient supplementaion such as vitamin A in children below five years and iron/folic acid in women. In all women of reproductive age, it may be important to explore the possibility of implementing the WHO recommendation of weekly IFA supplementation.
5. Public health measures which deals with factors which predespose population to manutrition. These includes; deworming, hygienic practises such as hand washing, use of ITNs
6. Other nutrition sensitive interventions that would improve the economic levels of the households e.g. livelihoods promotion, agricultural based programs, poverty alleviation and income generating approaches such as; conditional cash transfers, micro-credit facilities and agriculture/home food production such as kitchen gardens.

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Appendix 1: Dietary Reference Intakes (DRI's) for Minerals and Vitamins

Appendix 1a: Minerals

Life Stage Group	Ca (mg/d)	Cu (ug/d)		Fe (mg/d)		I (ug/d)		Mg (mg/d)		Mn (mg/d)	P (mg/d)		Se (ug/d)		Zn (mg/d)	
Infants	**AI**	**AI**		**AI**		**AI**		**AI**		**AI**	**AI**		**AI**			
0-6 mo	210	200		0.27		110		30		0.003	100		15 (ug/kg/d)		AI=2	
7-12 mo	270	220		RDA=11	EAR=6.9	130		75		0.6	275		20 (ug/kg/d)		RDA=3	EAR=2.2
Children	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**
1-3 yrs	500	340	260	7	3	90	65	80	65	1.2	460	380	20	17	3	2.2
4-8 yrs	800	440	340	10	4.1	90	65	130	110	1.5	500	405	30	23	5	4
Males																
9-13 y	1300	700	540	8	5.9	120	73	240	200	1.9	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.7	150	95	410	340	2.2	1250	1055	55	45	11	8.5
19-30 y	1000	900	700	8	6	150	95	400	330	2.3	700	580	55	45	11	9.4
31-50 y	1000	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
51-70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
> 70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
Females																
9-13 y	1300	700	540	8	5.7	120	73	240	200	1.6	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.9	150	95	360	300	1.6	1250	1055	55	45	9	7.5
19-30 y	1000	900	700	18	8.1	150	95	310	255	1.8	700	580	55	45	8	6.8
31-50 y	1000	900	700	18	8.1	150	95	320	265	1.8	700	580	55	45	8	6.8
51-70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
> 70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
Pregnancy																
< 18 y	1300	1000	785	27	23	220	160	400	335	2	1250	1055	60	49	13	10.5
19-30 y	1000	1000	800	27	23	220	160	350	290	2	700	580	60	49	11	9.5
31-50 y	1000	1000	800	27	23	220	160	360	300	2	700	580	60	49	11	9.5
Lactation																
< 18 y	1300	1300	985	10	7	290	209	360	300	2.6	1250	1055	70	59	14	11.6
19-30 y	1000	1300	1000	9	6.5	290	209	310	255	2.6	700	580	70	59	12	10.4
31-50 y	1000	1300	1000	9	6.5	290	209	320	265	2.6	700	580	70	59	12	10.4

Appendix 1b: Vitamins

Life Stage Group	Vit A (ug/d)		Thia (mg/d)		Ribo (mg/d)		Nia (mg/d)		Vit B^6 (mg/d)		Folate (ug/d)		Vit B_{12} (ug/d)		Panto Acid (mg/d)	Biotin (ug/d)	VC (mg/d)		Vit D (ug/d)	Vit E (mg/d)	
Infants	AI		AI		AI		AI		AI		AI		AI		AI	AI	AI		AI	AI	
0-6 mo	400		0.2		0.3		2		0.1		65		0.4		1.7	5	40		5	4	
7-12 mo	500		0.3		0.4		4		0.3		80		0.5		1.8	6	50		5	6	
Children	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	AI	AI	RDA	EAR	AI	RDA	
1-3 yrs	300	210	0.5	0.4	0.5	0.4	6	5	0.5	0.4	150	120	0.9	0.7	2	8	15	13	5	6	5
4-8 yrs	400	275	0.6	0.5	0.6	0.5	8	6	0.6	0.5	200	160	1.2	1	3	12	25	22	5	7	6
Males																					
9-13 y	600	445	0.9	0.7	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	900	630	1.2	1	1.3	1.1	16	12	1.3	1.1	400	330	2.4	2	5	25	75	63	5	15	12
19-30 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
31-50 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
51-70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	10	15	12
> 70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	15	15	12
Females																					
9-13 y	600	420	0.9	0.4	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	700	485	1	0.9	1	0.9	14	11	1.2	1	400	330	2.4	2	5	25	65	56	5	15	12
19-30 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
31-50 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
51-70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	10	15	12
> 70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	15	15	12
Pregnancy																					
< 18 y	750	530	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	80	66	5	15	12
19-30 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
31-50 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
Lactation																					
< 18 y	1200	880	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	115	96	5	19	16
19-30 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16
31-50 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16

Compiled from: 1. A Report of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes and its Panel on Folate, Other B Vitamins, and Choline and Subcommittee on Upper Reference Levels of Nutrients, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline (2000, 592 pp): 2. Panel on Dietary Antioxidants and Related Compounds, Subcommittees on Upper Reference Levels of Nutrients and Interpretation and Uses of DRIs, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. (2000, 529 pp.): 3. A Report of the Subcommittees on Interpretation and Uses of Dietary Reference Intakes and Upper Reference Levels of Nutrients, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes: Applications in Dietary Assessment. (2001, 306 pp.): 4. Panel on Micronutrients, Subcommittees on Upper Reference Levels of Nutrients and of Interpretation and Use of Dietary Reference Intakes, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. (2002, 650 pp.):5. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. (1997, 448 pp.

Appendix 2

Appendix 2a: Sources of dietary energy by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	5%	2%	3%	4%	3%	7%	5%	6%	5%
Beverages	0%	1%	1%	0%	1%	1%	1%	0%	0%
Eggs	0%	1%	0%	0%	0%	0%	1%	0%	0%
Fats and oils	4%	6%	8%	6%	7%	8%	9%	8%	7%
Fruits and fresh/pure fruit juices	3%	4%	2%	1%	5%	2%	2%	1%	1%
Grains and grain products	54%	50%	58%	66%	56%	57%	60%	67%	65%
Meats, poultry, and insects	0%	2%	3%	1%	4%	2%	3%	5%	2%
Milk and dairy	22%	21%	14%	10%	12%	8%	8%	5%	8%
Miscellaneous	0%	0%	0%	1%	0%	0%	1%	0%	0%
Sugars and sweets	8%	10%	7%	9%	8%	7%	7%	5%	8%
Vegetables	3%	4%	3%	2%	5%	6%	4%	3%	3%

Appendix 2b: Sources of dietary lipid by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	7%	1%	2%	1%	0%	8%	1%	1%	1%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	2%	1%	2%	1%	1%	2%	0%	1%
Fats and oils	17%	26%	35%	34%	34%	36%	40%	38%	38%
Fruits and fresh/pure fruit juices	0%	0%	0%	0%	1%	0%	0%	0%	0%
Grains and grain products	21%	17%	20%	30%	21%	23%	23%	29%	28%
Meats, poultry, and insects	0%	5%	8%	1%	8%	5%	9%	14%	7%
Milk and dairy	46%	42%	30%	27%	27%	16%	18%	11%	22%
Miscellaneous	0%	1%	2%	4%	0%	0%	3%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	7%	5%	2%	1%	7%	10%	4%	7%	3%

Appendix 2c: Sources of dietary iron by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	20%	8%	11%	10%	8%	14%	14%	19%	15%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	2%	1%	1%	0%	0%	1%	0%	1%
Fats and oils	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fruits and fresh/pure fruit juices	2%	4%	2%	0%	4%	1%	1%	0%	1%
Grains and grain products	65%	63%	63%	67%	61%	54%	57%	61%	62%
Meats, poultry, and insects	2%	7%	6%	1%	6%	4%	5%	8%	5%
Milk and dairy	2%	0%	1%	1%	0%	0%	0%	0%	0%
Miscellaneous	0%	0%	1%	1%	0%	0%	1%	0%	0%
Sugars and sweets	0%	0%	0%	7%	0%	8%	3%	0%	2%
Vegetables	9%	16%	16%	11%	21%	19%	17%	11%	13%

Appendix 2d: Sources of dietary zinc by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	17%	4%	6%	8%	5%	13%	9%	11%	9%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	1%	0%	1%	1%	1%	1%	0%	1%
Fats and oils	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fruits and fresh/pure fruit juices	1%	2%	1%	1%	3%	1%	1%	1%	2%
Grains and grain products	44%	43%	50%	64%	52%	51%	53%	54%	58%
Meats, poultry, and insects	3%	9%	12%	3%	13%	11%	13%	23%	11%
Milk and dairy	31%	34%	23%	17%	18%	13%	13%	7%	14%
Miscellaneous	0%	0%	0%	1%	0%	0%	1%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	4%	6%	7%	6%	8%	10%	8%	5%	6%

Appendix 2e: Sources of dietary calcium by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	6%	1%	2%	3%	2%	6%	4%	9%	5%
Beverages	0%	3%	3%	0%	2%	0%	1%	0%	0%
Eggs	0%	1%	0%	0%	0%	0%	1%	0%	1%
Fats and oils	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fruits and fresh/pure fruit juices	2%	2%	1%	1%	1%	1%	1%	3%	1%
Grains and grain products	4%	7%	9%	23%	12%	18%	16%	13%	16%
Meats, poultry, and insects	0%	0%	0%	0%	1%	0%	1%	1%	1%
Milk and dairy	82%	76%	67%	53%	57%	46%	47%	47%	54%
Miscellaneous	0%	1%	1%	2%	2%	1%	2%	5%	1%
Sugars and sweets	0%	0%	0%	1%	0%	1%	0%	0%	0%
Vegetables	6%	10%	17%	16%	22%	26%	26%	22%	21%

Appendix 2f: Sources of dietary vitamin A by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	4%	0%	0%	0%	0%	0%	0%	0%	0%
Beverages	0%	0%	1%	0%	0%	0%	0%	0%	0%
Eggs	0%	1%	0%	0%	0%	0%	0%	0%	0%
Fats and oils	4%	3%	2%	3%	1%	4%	2%	6%	3%
Fruits and fresh/pure fruit juices	2%	3%	4%	1%	1%	1%	2%	1%	1%
Grains and grain products	0%	0%	0%	3%	0%	0%	1%	0%	1%
Meats, poultry, and insects	0%	7%	4%	0%	0%	0%	1%	0%	2%
Milk and dairy	9%	7%	5%	4%	2%	2%	2%	2%	3%
Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	79%	79%	83%	89%	94%	94%	91%	91%	90%

Appendix 3: Dietary Reference Intakes (DRI's) for Minerals and Vitamins

Appendix 3a: Minerals

Life Stage Group	Ca (mg/d)	Cu (ug/d)		Fe (mg/d)		I (ug/d)		Mg (mg/d)		Mn (mg/d)	P (mg/d)		Se (ug/d)		Zn (mg/d)	
Infants	**AI**	**AI**		**AI**		**AI**		**AI**		**AI**	**AI**		**AI**			
0-6 mo	210	200		0.27		110		30		0.003	100		15 (ug/kg/d)		AI=2	
7-12 mo	270	220		RDA=11	EAR=6.9	130		75		0.6	275		20 (ug/kg/d)		RDA=3	EAR=2.2
Children	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**
1-3 yrs	500	340	260	7	3	90	65	80	65	1.2	460	380	20	17	3	2.2
4-8 yrs	800	440	340	10	4.1	90	65	130	110	1.5	500	405	30	23	5	4
Males																
9-13 y	1300	700	540	8	5.9	120	73	240	200	1.9	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.7	150	95	410	340	2.2	1250	1055	55	45	11	8.5
19-30 y	1000	900	700	8	6	150	95	400	330	2.3	700	580	55	45	11	9.4
31-50 y	1000	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
51-70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
> 70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
Females																
9-13 y	1300	700	540	8	5.7	120	73	240	200	1.6	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.9	150	95	360	300	1.6	1250	1055	55	45	9	7.5
19-30 y	1000	900	700	18	8.1	150	95	310	255	1.8	700	580	55	45	8	6.8
31-50 y	1000	900	700	18	8.1	150	95	320	265	1.8	700	580	55	45	8	6.8
51-70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
> 70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
Pregnancy																
< 18 y	1300	1000	785	27	23	220	160	400	335	2	1250	1055	60	49	13	10.5
19-30 y	1000	1000	800	27	23	220	160	350	290	2	700	580	60	49	11	9.5
31-50 y	1000	1000	800	27	23	220	160	360	300	2	700	580	60	49	11	9.5
Lactation																
< 18 y	1300	1300	985	10	7	290	209	360	300	2.6	1250	1055	70	59	14	11.6
19-30 y	1000	1300	1000	9	6.5	290	209	310	255	2.6	700	580	70	59	12	10.4
31-50 y	1000	1300	1000	9	6.5	290	209	320	265	2.6	700	580	70	59	12	10.4

Appendix 3b: Vitamins

Life Stage Group	Vit A (ug/d)		Thia (mg/d)		Ribo (mg/d)		Nia (mg/d)		Vit B6 (mg/d)		Folate (ug/d)		Vit B_{12} (ug/d)		Panto Acid (mg/d)	Biotin (ug/d)	VC (mg/d)		Vit D (ug/d)	Vit E (mg/d)	
Infants	**AI**		**AI**		**AI**		**AI**		**AI**		**AI**		**AI**		**AI**	**AI**	**AI**		**AI**	**AI**	
0-6 mo	400		0.2		0.3		2		0.1		65		0.4		1.7	5	40		5	4	
7-12 mo	500		0.3		0.4		4		0.3		80		0.5		1.8	6	50		5	6	
Children	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**AI**	**AI**	**RDA**	**EAR**	**AI**	**RDA**	
1-3 yrs	300	210	0.5	0.4	0.5	0.4	6	5	0.5	0.4	150	120	0.9	0.7	2	8	15	13	5	6	5
4-8 yrs	400	275	0.6	0.5	0.6	0.5	8	6	0.6	0.5	200	160	1.2	1	3	12	25	22	5	7	6
Males																					
9-13 y	600	445	0.9	0.7	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	900	630	1.2	1	1.3	1.1	16	12	1.3	1.1	400	330	2.4	2	5	25	75	63	5	15	12
19-30 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
31-50 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
51-70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	10	15	12
> 70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	15	15	12
Females																					
9-13 y	600	420	0.9	0.4	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	700	485	1	0.9	1	0.9	14	11	1.2	1	400	330	2.4	2	5	25	65	56	5	15	12
19-30 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
31-50 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
51-70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	10	15	12
> 70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	15	15	12
Pregnancy																					
< 18 y	750	530	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	80	66	5	15	12
19-30 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
31-50 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
Lactation																					
< 18 y	1200	880	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	115	96	5	19	16
19-30 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16
31-50 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16

Compiled from: 1. A Report of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes and its Panel on Folate, Other B Vitamins, and Choline and Subcommittee on Upper Reference Levels of Nutrients, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline (2000, 592 pp): 2. Panel on Dietary Antioxidants and Related Compounds, Subcommittees on Upper Reference Levels of Nutrients and Interpretation and Uses of DRIs, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. (2000, 529 pp.): 3. A Report of the Subcommittees on Interpretation and Uses of Dietary Reference Intakes and Upper Reference Levels of Nutrients, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes: Applications in Dietary Assessment. (2001, 306 pp.): 4. Panel on Micronutrients, Subcommittees on Upper Reference Levels of Nutrients and of Interpretation and Use of Dietary Reference Intakes, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. (2002, 650 pp.):5. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. (1997, 448 pp.

Appendix 4

Appendix 4a: Sources of dietary energy by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	5%	2%	3%	4%	3%	7%	5%	6%	5%
Beverages	0%	1%	1%	0%	1%	1%	1%	0%	0%
Eggs	0%	1%	0%	0%	0%	0%	1%	0%	0%
Fats and oils	4%	6%	8%	6%	7%	8%	9%	8%	7%
Fruits and fresh/pure fruit juices	3%	4%	2%	1%	5%	2%	2%	1%	1%
Grains and grain products	54%	50%	58%	66%	56%	57%	60%	67%	65%
Meats, poultry, and insects	0%	2%	3%	1%	4%	2%	3%	5%	2%
Milk and dairy	22%	21%	14%	10%	12%	8%	8%	5%	8%
Miscellaneous	0%	0%	0%	1%	0%	0%	1%	0%	0%
Sugars and sweets	8%	10%	7%	9%	8%	7%	7%	5%	8%
Vegetables	3%	4%	3%	2%	5%	6%	4%	3%	3%

Appendix 4b: Sources of dietary lipid by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	7%	1%	2%	1%	0%	8%	1%	1%	1%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	2%	1%	2%	1%	1%	2%	0%	1%
Fats and oils	17%	26%	35%	34%	34%	36%	40%	38%	38%
Fruits and fresh/pure fruit juices	0%	0%	0%	0%	1%	0%	0%	0%	0%
Grains and grain products	21%	17%	20%	30%	21%	23%	23%	29%	28%
Meats, poultry, and insects	0%	5%	8%	1%	8%	5%	9%	14%	7%
Milk and dairy	46%	42%	30%	27%	27%	16%	18%	11%	22%
Miscellaneous	0%	1%	2%	4%	0%	0%	3%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	7%	5%	2%	1%	7%	10%	4%	7%	3%

Appendix 4c: Sources of dietary iron by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	20%	8%	11%	10%	8%	14%	14%	19%	15%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	2%	1%	1%	0%	0%	1%	0%	1%
Fats and oils	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fruits and fresh/pure fruit juices	2%	4%	2%	0%	4%	1%	1%	0%	1%
Grains and grain products	65%	63%	63%	67%	61%	54%	57%	61%	62%
Meats, poultry, and insects	2%	7%	6%	1%	6%	4%	5%	8%	5%
Milk and dairy	2%	0%	1%	1%	0%	0%	0%	0%	0%
Miscellaneous	0%	0%	1%	1%	0%	0%	1%	0%	0%
Sugars and sweets	0%	0%	0%	7%	0%	8%	3%	0%	2%
Vegetables	9%	16%	16%	11%	21%	19%	17%	11%	13%

Appendix 4d: Sources of dietary zinc by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	17%	4%	6%	8%	5%	13%	9%	11%	9%
Beverages	0%	0%	0%	0%	0%	0%	0%	0%	0%
Eggs	1%	1%	0%	1%	1%	1%	1%	0%	1%
Fats and oils	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fruits and fresh/pure fruit juices	1%	2%	1%	1%	3%	1%	1%	1%	2%
Grains and grain products	44%	43%	50%	64%	52%	51%	53%	54%	58%
Meats, poultry, and insects	3%	9%	12%	3%	13%	11%	13%	23%	11%
Milk and dairy	31%	34%	23%	17%	18%	13%	13%	7%	14%
Miscellaneous	0%	0%	0%	1%	0%	0%	1%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	4%	6%	7%	6%	8%	10%	8%	5%	6%

Appendix 4e: Sources of dietary vitamin A by food group and age group. When source contributes more than 10% of total energy the value is shown in red text.

Food Group	6-11m	12-23m	24-35m	36-47m	48-59m	NPNL15-19	NPNL19+	PL15-19	PL19+
Beans, nuts, and seeds	4%	0%	0%	0%	0%	0%	0%	0%	0%
Beverages	0%	0%	1%	0%	0%	0%	0%	0%	0%
Eggs	0%	1%	0%	0%	0%	0%	0%	0%	0%
Fats and oils	4%	3%	2%	3%	1%	4%	2%	6%	3%
Fruits and fresh/pure fruit juices	2%	3%	4%	1%	1%	1%	2%	1%	1%
Grains and grain products	0%	0%	0%	3%	0%	0%	1%	0%	1%
Meats, poultry, and insects	0%	7%	4%	0%	0%	0%	1%	0%	2%
Milk and dairy	9%	7%	5%	4%	2%	2%	2%	2%	3%
Miscellaneous	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sugars and sweets	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vegetables	79%	79%	83%	89%	94%	94%	91%	91%	90%

Appendix 5: Summary of key findings in Kenya National Micronutrient Survey 2011

Indicators	Kenya				Rural				Urban			
	n	%	95% CI		n	%	95% CI		n	%	95% CI	
Nutritional status												
Pre School Children [10]												
Height-for-age <-2 SD	1130	26.3	23.7	28.9	788	30.0	26.8	33.2	342	16.9	12.9	20.9
Weight-for-height <-2 SD	1130	6.3	4.9	7.7	788	6.0	4.3	7.7	342	7.1	4.4	9.8
Weight-for-age <-2 SD	1130	12.7	10.8	14.6	788	13.2	10.8	15.6	342	11.4	8.0	14.8
Pregnant Women[7] (MUAC <23 cm)	117	11.7	5.9	17.5	71	11.4	4.0	18.8	46	12.0	2.6	21.4
Non-pregnant Women[11] (BMI<18)	695	13.2	10.7	15.7	410	16.1	12.5	19.7	285	9.1	5.8	12.4
Men[12] (BMI<18)	279	24.7	19.6	29.8	184	30.4	23.8	37.0	95	13.7	6.8	20.6
Anaemia[13]												
Pre-School Children	827	26.3	23.3	29.3	592	26.9	23.3	30.5	234	24.8	19.3	30.3
School Age Children[14]	872	16.5	14.0	19.0	643	18.5	15.5	21.5	230	10.9	6.9	14.9
Pregnant Women	104	41.6	32.1	51.1	61	50.8	38.3	63.4	44	29.5	16.0	43.0
Non-pregnant Women	592	21.9	18.6	25.2	370	24.6	20.2	29.0	221	17.2	12.2	22.2
Men	240	9.3	5.9	13.3	144	11.8	6.5	17.1	96	5.2	0.8	9.6
Total	**2635**	**23.1**	**21.5**	**24.7**	**1810**	**26.5**	**24.5**	**28.5**	**825**	**17.5**	**14.9**	**20.1**
Iron Deficiency[15]												
Pre-School Children	918	21.8	19.1	24.5	662	21.5	18.4	24.6	255	22.7	17.6	27.8
School Age Children	942	9.4	7.5	11.3	694	9.9	7.7	12.1	248	7.7	4.4	11.0
Pregnant Women	111	36.1	27.2	45.0	68	45.6	33.8	57.4	43	20.9	8.8	33.0
Non-pregnant Women	633	21.3	18.1	24.5	397	21.4	17.4	25.4	236	21.2	16.0	26.4
Men	247	3.6	1.3	5.9	148	4.7	1.3	8.1	99	2.0	0.0	4.8
Total	**2851**	**18.4**	**17.0**	**19.8**	**1969**	**20.6**	**18.8**	**22.4**	**881**	**14.9**	**12.6**	**17.3**
Iron Deficiency Anaemia[16]												
Pre-School Children	827	13.3	11.0	15.6	592	12.5	9.8	15.2	234	12.4	8.2	16.6
School Age Children	942	4.9	3.5	6.3	618	5.3	3.5	7.1	233	3.9	1.4	6.4
Pregnant Women	104	26.0	17.6	34.4	60	36.7	24.5	48.9	44	11.4	2.0	20.8
Non-pregnant Women	592	14.0	11.2	16.8	363	13.2	9.7	16.7	229	15.3	10.6	20.0
Men	243	2.9	0.8	5.0	144	3.5	0.5	6.5	98	2.0	0.0	4.8
Total	**2708**	**12.2**	**11.0**	**13.4**	**1777**	**14.2**	**12.6**	**15.8**	**838**	**9.0**	**7.1**	**11.0**
Vitamin A Deficiency												
Pre-School Children	918	9.2	7.3	11.1	663	8.1	6.0	10.2	256	12.1	8.1	16.1
School Age Children	942	4.7	3.4	6.1	695	5.0	3.4	6.6	248	3.6	1.3	5.9
Pregnant Women	111	5.4	1.2	9.6	68	0.0	N/A	N/A	43	14.0	3.6	24.4
Non-pregnant Women	632	1.1	0.3	1.9	397	1.8	0.5	3.1	236	0.4	0.0	1.2
Men	247	0.0	N/A	N/A	148	0.0	N/A	N/A	99	0.0	N/A	N/A
Total	**2850**	**4.1**	**3.4**	**4.8**	**1971**	**3.0**	**2.3**	**3.8**	**882**	**6.0**	**4.4**	**7.8**
Folate Deficiency												
Pregnant Women	78	32.1	21.7	42.5	50	36.0	22.7	49.3	28	25.0	9.0	41.0
Non-pregnant Women	445	30.9	26.6	35.2	279	25.1	20.0	30.2	165	40.6	33.1	48.1
Total	**523**	**31.5**	**27.5**	**35.5**	**329**	**30.6**	**25.6**	**35.6**	**193**	**32.8**	**26.2**	**39.4**
Vitamin B_{12} Deficiency												
Pregnant Women	78	7.7	1.8	13.6	50	8.0	0.5	15.5	28	7.1	0.0	16.6
Non-pregnant Women	445	34.7	30.3	39.1	279	36.9	31.2	42.6	165	30.7	23.7	37.7
Total	**523**	**21.2**	**17.7**	**24.7**	**329**	**22.5**	**18.0**	**27.0**	**193**	**18.9**	**13.4**	**24.4**

10 Children 6-59 months

11 Women of reproductive age (15-49 years)

12 Men aged 15-54 years

13 Using age specific Hb cut-offs. Hb adjusted for altitude

14 Children 5-14 years

15 Using age specific serum ferritin cut-offs. Serum ferritin corrected for inflammation

16 Use both Hb and serum ferritin cut-offs

Appendix 6: Dietary Reference Intakes (DRI's) for Minerals and Vitamins

Appendix 6a: Minerals

Life Stage Group	Ca (mg/d)	Cu (ug/d)		Fe (mg/d)		I (ug/d)		Mg (mg/d)		Mn (mg/d)	P (mg/d)		Se (ug/d)		Zn (mg/d)	
Infants	**AI**	**AI**		**AI**		**AI**		**AI**		**AI**	**AI**		**AI**			
0-6 mo	210	200		0.27		110		30		0.003	100		15 (ug/kg/d)		AI=2	
7-12 mo	270	220		RDA=11	EAR=6.9	130		75		0.6	275		20 (ug/kg/d)		RDA=3	EAR=2.2
Children	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**	**AI**	**RDA**	**EAR**	**RDA**	**EAR**	**RDA**	**EAR**
1-3 yrs	500	340	260	7	3	90	65	80	65	1.2	460	380	20	17	3	2.2
4-8 yrs	800	440	340	10	4.1	90	65	130	110	1.5	500	405	30	23	5	4
Males																
9-13 y	1300	700	540	8	5.9	120	73	240	200	1.9	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.7	150	95	410	340	2.2	1250	1055	55	45	11	8.5
19-30 y	1000	900	700	8	6	150	95	400	330	2.3	700	580	55	45	11	9.4
31-50 y	1000	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
51-70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
> 70 y	1200	900	700	8	6	150	95	420	350	2.3	700	580	55	45	11	9.4
Females																
9-13 y	1300	700	540	8	5.7	120	73	240	200	1.6	1250	1055	40	35	8	7
14-18 y	1300	890	685	11	7.9	150	95	360	300	1.6	1250	1055	55	45	9	7.5
19-30 y	1000	900	700	18	8.1	150	95	310	255	1.8	700	580	55	45	8	6.8
31-50 y	1000	900	700	18	8.1	15F0	95	320	265	1.8	700	580	55	45	8	6.8
51-70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
> 70 y	1200	900	700	8	5	150	95	320	265	1.8	700	580	55	45	8	6.8
Pregnancy																
< 18 y	1300	1000	785	27	23	220	160	400	335	2	1250	1055	60	49	13	10.5
19-30 y	1000	1000	800	27	23	220	160	350	290	2	700	580	60	49	11	9.5
31-50 y	1000	1000	800	27	23	220	160	360	300	2	700	580	60	49	11	9.5
Lactation																
< 18 y	1300	1300	985	10	7	290	209	360	300	2.6	1250	1055	70	59	14	11.6
19-30 y	1000	1300	1000	9	6.5	290	209	310	255	2.6	700	580	70	59	12	10.4
31-50 y	1000	1300	1000	9	6.5	290	209	320	265	2.6	700	580	70	59	12	10.4

Appendix 6b: Vitamins

Life Stage Group	Vit A (ug/d)		Thia (mg/d)		Ribo (mg/d)		Nia (mg/d)		Vit B6 (mg/d)		Folate (ug/d)		Vit B12 (ug/d)		Panto Acid (mg/d)	Biotin (ug/d)	VC (mg/d)		Vit D (ug/d)	Vit E (mg/d)	
Infants	AI		AI		AI		AI		AI		AI		AI		AI	AI	AI		AI	AI	
0-6 mo	400		0.2		0.3		2		0.1		65		0.4		1.7	5	40		5	4	
7-12 mo	500		0.3		0.4		4		0.3		80		0.5		1.8	6	50		5	6	
Children	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	RDA	EAR	AI	AI	RDA	EAR	AI	RDA	
1-3 yrs	300	210	0.5	0.4	0.5	0.4	6	5	0.5	0.4	150	120	0.9	0.7	2	8	15	13	5	6	5
4-8 yrs	400	275	0.6	0.5	0.6	0.5	8	6	0.6	0.5	200	160	1.2	1	3	12	25	22	5	7	6
Males																					
9-13 y	600	445	0.9	0.7	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	900	630	1.2	1	1.3	1.1	16	12	1.3	1.1	400	330	2.4	2	5	25	75	63	5	15	12
19-30 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
31-50 y		625	1.2	1	1.3	1.1	16	12	1.3	1.1	400	320	2.4	2	5	30	90	75	5	15	12
51-70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	10	15	12
> 70 y		625	1.2	1	1.3	1.1	16	12	1.7	1.4	400	320	2.4	2	5	30	90	75	15	15	12
Females																					
9-13 y	600	420	0.9	0.4	0.9	0.8	12	9	1	0.8	300	250	1.8	1.5	4	20	45	39	5	11	9
14-18 y	700	485	1	0.9	1	0.9	14	11	1.2	1	400	330	2.4	2	5	25	65	56	5	15	12
19-30 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
31-50 y		500	1.1	0.9	1.1	0.9	14	11	1.3	1.1	400	320	2.4	2	5	30	75	60	5	15	12
51-70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	10	15	12
> 70 y		500	1.1	0.9	1.1	0.9	14	11	1.5	1.3	400	320	2.4	2	5	30	75	60	15	15	12
Pregnancy																					
< 18 y	750	530	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	80	66	5	15	12
19-30 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
31-50 y	770	550	1.4	1.2	1.4	1.2	18	14	1.9	1.6	600	520	2.6	2.2	6	30	85	70	5	15	12
Lactation																					
< 18 y	1200	880	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	115	96	5	19	16
19-30 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16
31-50 y	1300	900	1.4	1.2	1.6	1.3	17	13	2	1.7	500	450	2.8	2.4	7	35	120	100	5	19	16

Compiled from: 1. A Report of the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes and its Panel on Folate, Other B Vitamins, and Choline and Subcommittee on Upper Reference Levels of Nutrients, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline (2000, 592 pp): 2. Panel on Dietary Antioxidants and Related Compounds, Subcommittees on Upper Reference Levels of Nutrients and Interpretation and Uses of DRIs, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. (2000, 529 pp.): 3. A Report of the Subcommittees on Interpretation and Uses of Dietary Reference Intakes and Upper Reference Levels of Nutrients, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes: Applications in Dietary Assessment. (2001, 306 pp.): 4. Panel on Micronutrients, Subcommittees on Upper Reference Levels of Nutrients and of Interpretation and Use of Dietary Reference Intakes, and the Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. (2002, 650 pp.):5. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. (1997, 448 pp.

Appendix 7: Population groups and the key measurement variables

Study Objective	Population Sub-set for Data Collection		National
Objective 1-3 Anaemia, iron deficiency, and vitamin A deficiency	Preschool children aged 6-59 months		✓
	Children aged 5-14 years old		✓
	Women of reproductive age 15-49 years (including non-pregnant)		✓
	Pregnant women age 15 – 49 years		✓
	Men 15-54 years old		✓
Objective 4 Iodine deficiency	Children 5-14 years		✓
	Women of reproductive age 15-49 years (including non-pregnant)		✓
	Pregnant women age 15-49 years		✓
Objective 5-6 Folate and vitamin B_{12} deficiency	Women of reproductive age 15-49 years (including non-pregnant)		✓
	Pregnant women age 15-49 years		✓
	Preschool children aged 6-59 months		✓
Objective 7 Supplementation coverage	Preschool children 6-59 months old (Vit. A Supplem. Coverage)		✓
	Women delivered in past 12 months (Vit. A Suppl. Coverage)		✓
	Women delivered in past 12 months (Perinatal Iron Suppl. coverage)		✓
Objective 8-9 Relative roles of salt consumed in households on the iodine status	Children 5 - 14 years old and Women 15 – 49 years old		✓
Objective 10 Wasting, stunting and underweight and BMI	Children 6 – 59 moths (Wasting, Stunting & Underweight)		✓
	Non-pregnant women 15 – 49 years old (BMI)		✓
Objective 11 Factors contributing to anaemia	Preschool children 6 – 59 months	Malaria	✓
		HIV	✓
		Haemoglobinopathies	✓
		Intestinal parasites	✓
	Children 5 – 14 years	Malaria	✓
		HIV	✓
		Intestinal parasites	✓
		Schistosomiasis	✓
	Women Reproductive age include pregnant and non-pregnant aged 15 – 49 years	Malaria	✓
		HIV	✓
		Haemoglobinopathies	✓
		Intestinal parasites	✓
		Schistosomiasis	✓
Objective 12 Zinc deficiency	Preschool children aged 6-59 years		✓
	Children aged 5-14 years old		✓
	All reproductive age women 15 – 49 years old		✓
	Men 15 – 49 years old		✓
Objective 13 Household and/or individual dietary consumption	Household (food consumption and/or 24 hour recall methodology)		
	Multiple target groups (food consumption and/or 24 hour recall methodology)		
Objective 14 Magnitude of infection	Preschool children aged 6-59 months		✓
	Children aged 5-14 years old		✓
	Women of reproductive age 15-49 years (including non-pregnant)		✓
	Pregnant women age 15 – 49 years		✓
	Men 15-54 years old		✓

Appendix 8: Sample sizes and precision for maximum sample size for each target group

Population group	Age Group	Indicator	Prevalence estimate	Precision per stratum (+ X%) Value for Maximum sample size	Design Effect	Response rate	Sample size per Stratum	Total sample size for National estimates and precision (%)	Total number of HH	Number of HH per cluster	Mean HH size	Target group as % of the total Population	Samples to be taken per individual
Preschool Children	6-59 Mons	Anaemia	65%	Rural: 4.0% Urban: 6.1%	2	90%	Rural: 1088 Urban:467	1,554 (3.4%)	2,960	10 per cluster	4.2	14.2%	Blood 2ml Stool: 30gms
School Children	5-14 years	Iodine deficiency	25%	Rural: 4.4% Urban:6.7%	2	80%	Rural: 751 Urban:322	1,072 (3.7%)	1,184	4 per cluster	4.2	29.0%	Blood 5ml Urine 30 ml Stool: 30gms
Non-Pregnant Women	15-49 years	Iron deficiency	50%	Rural: 4.0% Urban:6.1%	2	90%	Rural: 1196 Urban:513	1,708 (3.4%)	1,184	4 per cluster	4.2	45.4%	Blood 9ml Urine 30 ml Stool: 30gms
Pregnant Women	15-49 years	Iron deficiency	50%	Rural: 9.9% Urban:15.1%	2	86%	Rural: 196 Urban:84	283 (8.3%)	2,960	10 per cluster	4.2	7% of all WRA	Blood 9ml Urine 30 ml Stool: 30gms
Men	15-54 years	Zinc deficiency	50%	Rural:7.1% Urban:10.8%	2	80%	Rural: 384 Urban:165	548 (5.9%)	528	2 per cluster	4.2	43.3%	Blood 6ml
Households		Fortified foods	50%	Rural: Urban:	2	90%	Rural: Urban:	2960	2960	10	n/a	n/a	Staple foods

Appendix 9: KEMRI ERC Approvals

KENYA MEDICAL RESEARCH INSTITUTE

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KEMRI/RES/7/3/1 August 9, 2011

TO: DR. YERI KOMBE, PRINCIPAL INVESTIGATOR
THE DIRECTOR, CPHR
NAIROBI

RE: SSC PROTOCOL 1967 (*REQUEST FOR 1ST AMENDMENT*):
THE KENYA NATIONAL MICRONUTRIENT SURVEY (KNMS)

This is to inform you that during the 192nd meeting of the KEMRI/ERC meeting held on 9th August 2011, the requested amendment for the above referenced study was reviewed.

The Committee is of the view that the proposed amendment is to change the unit of analysis from Provinces to a comparison between rural and urban populations when determining prevalence estimates of anemia, iron, Vitamin A and zinc deficiency in the study population

The above amendments are justified and do not alter the risk/benefit assessment of the study participants and are therefore **granted approval** for implementation.

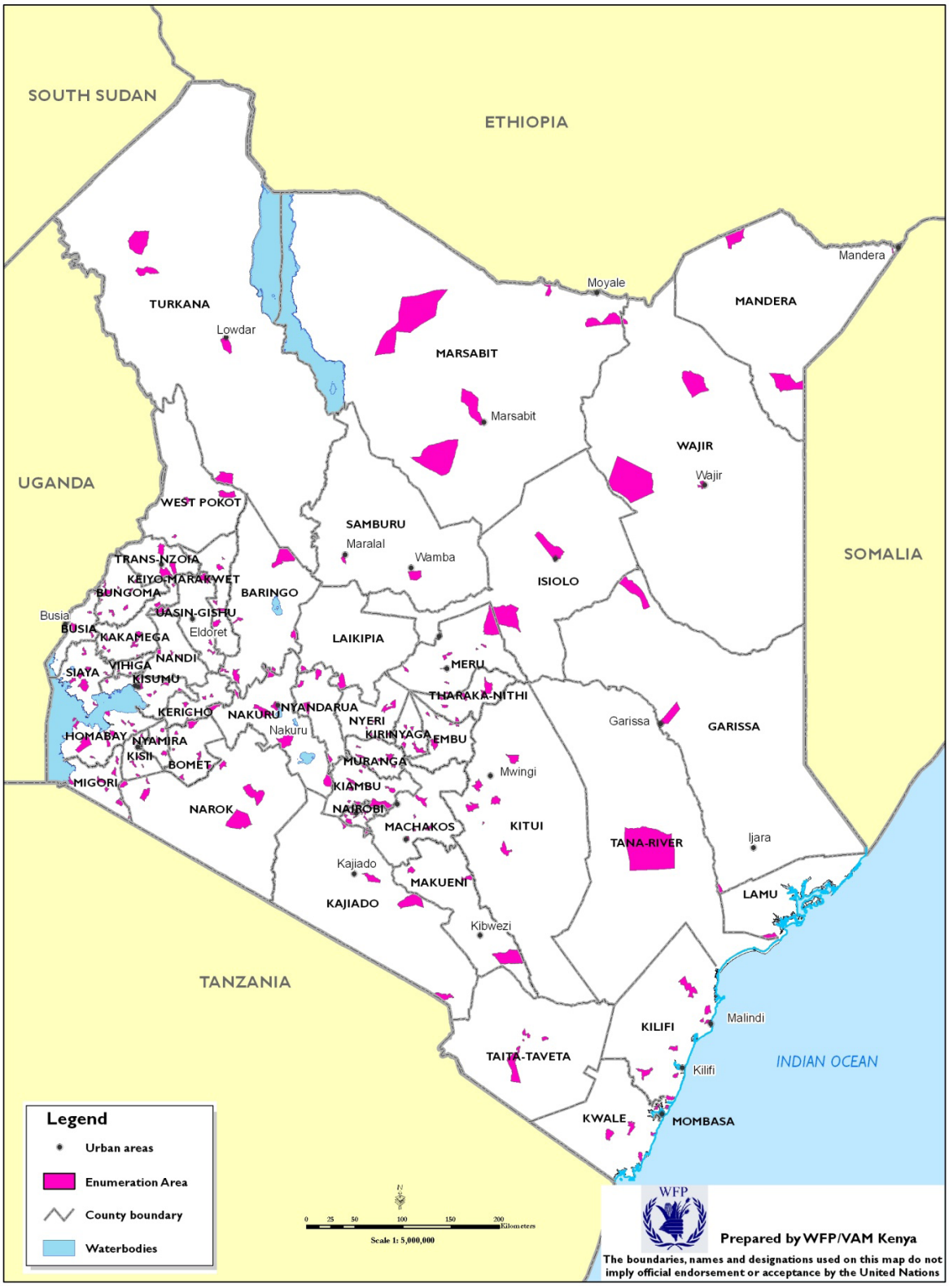
Please note that you are required to submit any further amendments to this protocol and other information pertinent to human participation in this study to the SSC and ERC for review prior to initiation.

Yours sincerely,

RCMKithinji

Caroline Kithinji
FOR: SECRETARY,
KEMRI/ETHICS REVIEW COMMITTEE

Appendix 10: A map of Kenya showing clusters covered in KNMS 2011



Appendix 11: Sampling Errors

Appendix 11A: Sampling Errors for Rural Kenya

Pre School Children (6-59 Months old)								
Variable	**Category**	**Estimate**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia PSC (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	26.8806	2.4963	827	1.8773	1.3701	21.9622	31.7991
	Normal	73.1194	2.4963	827	1.8773	1.3701	68.2009	78.0378
ID PSC (FER <15ug/L corrected for inflammation	Deficiency	21.4878	2.8124	918	3.1047	1.7620	15.9488	27.0267
	Normal	78.5122	2.8124	918	3.1047	1.7620	72.9733	84.0512
IDA PSC (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	12.5613	2.3212	827	2.9047	1.7043	7.9878	17.1348
	Normal	87.4387	2.3212	827	2.9047	1.7043	82.8652	92.0122
Vitamin A deficiency PSC (using RBP<0.70 µmol/L)	Severe	8.0951	1.3757	918	1.6845	1.2979	5.3857	10.8044
	Marginal	51.4280	2.6610	918	1.8772	1.3701	46.1870	56.6689
	Normal	40.4770	2.6294	918	1.9004	1.3785	35.2982	45.6557
Malaria status PSC	Positive	2.6651	0.9896	848	2.2789	1.5096	0.7155	4.6147
	Negative	97.3349	0.9896	848	2.2789	1.5096	95.3853	99.2845
HIV results PSC	Positive	1.4873	0.4934	903	1.0819	1.0401	1.5155	2.4591
	Negative	98.5127	0.4934	886	1.0819	1.0401	97.5409	99.4845
Sickle cell genotype PSC	AA	93.1430	1.3772	876	1.9111	1.3824	90.4304	95.8554
	AS	6.3121	1.2498	876	1.6997	1.3037	3.8506	8.7736
	SS	0.5449	0.3342	876	1.3265	1.1517	-0.1134	1.2032
Thalassaemia PSC	Het	27.4833	2.4482	862	1.8959	1.3769	22.6613	32.3052
	Homo	6.1772	1.2252	862	1.6328	1.2778	3.7641	8.5902
	Normal	66.3395	2.7201	862	2.0888	1.4453	60.9821	71.6969
Tape_worm_qualitative PSC	Present	22.3401	4.6188	722	6.3946	2.5288	13.2386	31.4416
	Absent	77.6599	4.6188	722	6.3946	2.5288	68.5583	86.7614
Hookworm_qualitative PSC	Present	24.6420	4.5716	722	5.8528	2.4193	15.6336	33.6504
	Absent	75.3580	4.5716	722	5.8528	2.4193	66.3495	84.3664
Schistosoma_mansoni_qualitative PSC	Present	22.9352	4.7747	722	6.7075	2.5899	13.5265	32.3437
	Absent	77.0649	4.7747	722	6.7075	2.5899	67.6562	86.4734
Calcium-RDA-24 hour recall PSC	Inadequate	74.7827	4.1987	281	1.9072	1.3810	66.5033	83.0620
	Adequate	25.2174	4.1987	281	1.9072	1.3810	16.9380	33.4967
Iron-RDA-24 hour recall PSC	Inadequate	47.9682	4.9778	281	2.0255	1.4232	38.1525	57.7838
	Adequate	52.0319	4.9778	281	2.0255	1.4232	42.2162	61.8475
Zinc-RDA-24 hour recall PSC	Inadequate	52.8084	4.8598	281	1.9335	1.3905	43.2254	62.3914
	Adequate	47.1916	4.8598	281	1.9335	1.3905	37.6086	56.7745
Vitamin A-24 hour recall PSC	Inadequate	75.0269	3.7163	281	1.5039	1.2263	67.6986	82.3551
	Adequate	24.9731	3.7163	281	1.5039	1.2263	17.6449	32.3013
School Aged Children (5- 14 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia SAC (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	19.6496	2.7604	872	3.1356	1.7708	14.2092	25.0899
	Normal	80.3505	2.7604	872	3.1356	1.7708	74.9101	85.7908

ID SAC (FER <15ug/L corrected for inflammation	Deficiency	9.9775	2.2174	942	3.7964	1.9484	5.6088	14.3463
	Normal	90.0225	2.2174	942	3.7964	1.9484	85.6537	94.3913
IDA SAC (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	5.1968	1.6837	872	3.7385	1.9335	1.8784	8.5152
	Normal	94.8032	1.6837	872	3.7385	1.9335	91.4848	98.1216
Vitamin A deficiency SAC (using RBP<0.70 µmol/L)	Severe	5.0017	1.1087	942	1.7941	1.3395	2.8173	7.1861
	Marginal	36.4523	2.7512	942	2.2661	1.5054	31.0318	41.8727
	Normal	58.5460	3.2332	942	2.9873	1.7284	52.1758	64.9162
Malaria status SAC	Positive	4.7410	1.6779	908	4.1666	2.0412	1.4345	8.0475
	Negative	95.2590	1.6779	908	4.1666	2.0412	91.9525	98.5655
HIV results SAC	Positive	0.5392	0.2602	981	0.9193	0.9588	0.0265	1.0519
	Negative	99.4608	0.2602	981	0.9193	0.9588	98.9481	99.9735
Sickle cell genotype SAC	AA	91.6215	1.8985	904	3.1236	1.7674	87.8809	95.3622
	AS	8.3785	1.8985	904	3.1236	1.7674	4.6378	12.1191
Thalassaemia SAC	Het	24.4654	2.5345	878	2.2465	1.4988	19.4713	29.4596
	Homo	3.4037	0.9306	878	1.7023	1.3047	1.5699	5.2374
	Normal	72.1309	2.8187	878	2.5542	1.5982	66.5768	77.6850
Pregnant Women (Age 15 -49 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia PW (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	50.2537	7.4459	104	1.3338	1.1549	35.4300	65.0774
	Normal	49.7463	7.4459	104	1.3338	1.1549	34.9226	64.5700
ID (FER <15ug/L corrected for inflammation) - PW	Deficiency	46.1295	7.8199	111	1.6531	1.2857	30.5760	61.6830
	Normal	53.8705	7.8199	111	1.6531	1.2857	38.3170	69.4240
IDA PW (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	36.7459	7.5414	104	1.4716	1.2131	21.7321	51.7597
	Normal	63.2541	7.5414	104	1.4716	1.2131	48.2403	78.2679
Vitamin A deficiency PW (using RBP<0.70 µmol/L)	Severe			111				
	Marginal	15.5810	4.9405	111	1.2466	1.1165	5.7546	25.4074
	Normal	84.4190	4.9405	111	1.2466	1.1165	74.5926	94.2454
Malaria status PW	Positive	0.6264	0.6334	110	0.4191	0.6474	-0.6333	1.8862
	Negative	99.3736	0.6334	110	0.4191	0.6474	98.1138	100.6333
HIV results PW	Positive	0	0	119	0	0	0	0
	Negative	100	0	118	0.5797	0.7614	100	100
Sickle cell genotype PW	AA	94.5982	2.9679	113	1.2801	1.1314	88.6983	100.4981
	AS	5.4018	2.9679	113	1.2801	1.1314	-0.4981	11.3017
Thalassaemia PW	Het	45.1788	7.0660	109	1.4366	1.1986	31.1321	59.2255
	Homo	1.3635	0.9792	109	0.5081	0.7128	-0.5831	3.3100
	Normal	53.4577	7.1248	109	1.4540	1.2058	39.2942	67.6213
Tape_worm_qualitative PW	Present	23.5846	7.5006	76	1.4862	1.2191	8.5911	38.5779
	Absent	76.4154	7.5006	76	1.4862	1.2191	61.4220	91.4089
Hookworm_qualitative PW	Present	26.5750	7.6474	76	1.4269	1.1945	11.2880	41.8619
	Absent	73.4250	7.6474	76	1.4269	1.1945	58.1380	88.7120
Schistosoma_mansoni_qualitative PW	Present	24.4291	7.6076	76	1.4925	1.2217	9.2218	39.6364
	Absent	75.5709	7.6076	76	1.4925	1.2217	60.3635	90.7782

Calcium-RDA-24 hour recall PW	Inadequate	87.4426	6.4341	39	1.0097	1.0048	74.3937	100.4915
	Adequate	12.5574	6.4341	39	1.0097	1.0048	-0.4915	25.6063
Iron-RDA-24 hour recall PW	Inadequate	97.3029	2.8317	39	0.5698	0.7549	91.4586	103.1472
	Adequate	2.6971	2.8317	39	0.5698	0.7549	-3.1472	8.5414
Zinc-RDA-24 hour recall PW	Inadequate	56.8568	11.8579	39	1.5351	1.2390	32.8080	80.9057
	Adequate	43.1432	11.8579	39	1.5351	1.2390	19.0943	67.1919
Vitamin A-24 hour recall PW	Inadequate	70.7236	11.0749	39	1.5864	1.2595	48.2627	93.1845
	Adequate	29.2764	11.0749	39	1.5864	1.2595	6.8155	51.7372
Non-pregnant Women (Age 15 -49 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia NPW (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	24.6228	3.2924	592	2.1606	1.4699	18.1369	31.1087
	Normal	75.3772	3.2924	592	2.1606	1.4699	68.8913	81.8631
ID NPW (FER <15ug/L corrected for inflammation	Deficiency	21.3736	3.1746	631	2.3684	1.5390	15.1217	27.6255
	Normal	78.6264	3.1746	631	2.3684	1.5390	72.3745	84.8783
IDA NPW (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	15.0275	2.6948	592	2.1038	1.4504	9.7190	20.3361
	Normal	84.9725	2.6948	592	2.1038	1.4504	79.6639	90.2810
Vitamin A deficiency NPW (using RBP<0.70 µmol/L)	Severe	1.7161	0.9668	631	2.1885	1.4794	-0.1878	3.6200
	Marginal	8.0287	1.8822	631	1.8947	1.3765	4.3220	11.7355
	Normal	90.2552	2.1128	631	2.0044	1.4158	86.0943	94.4161
Malaria status NPW	Positive	2.7439	0.8962	606	1.2415	1.1142	0.9792	4.5087
	Negative	97.2561	0.8962	606	1.2415	1.1142	95.4913	99.0208
HIV results NPW	Positive	0.0000	0.0000	660	0.0000	0.0000	0.0000	0.0000
	Negative	100.0000	0.0000	639	1.6394	1.2804	100.0000	100.0000
Sickle cell genotype	AA	93.9104	1.9145	602	2.4110	1.5527	90.1396	97.6812
	AS	6.0896	1.9145	574	2.4110	1.5527	2.3188	9.8604
Thalassaemia	Het	22.5388	2.7530	581	1.5760	1.2554	17.1159	27.9616
	Homo	4.2735	1.3291	581	1.5678	1.2521	1.6554	6.8916
	Normal	73.1877	3.2956	581	2.0094	1.4175	66.6959	79.6795
Tape_worm_qualitative NPW	Present	15.4502	4.1391	453	3.7427	1.9346	7.2909	23.6096
	Absent	84.5498	4.1391	453	3.7427	1.9346	76.3905	92.7091
Hookworm_qualitative NPW	Present	20.1312	4.1550	453	3.0642	1.7505	11.9407	28.3218
	Absent	79.8688	4.1550	453	3.0642	1.7505	71.6782	88.0593
Schistosoma_mansoni_qualitative NPW	Present	16.3728	4.1458	453	3.5824	1.8927	8.2003	24.5453
	Absent	83.6273	4.1458	453	3.5824	1.8927	75.4548	91.7997
Calcium-RDA-24 hour recall NPW	Inadequate	86.8134	2.9361	405	1.8711	1.3679	81.0315	92.5953
	Adequate	13.1866	2.9361	405	1.8711	1.3679	7.4047	18.9685
Iron-RDA-24 hour recall NPW	Inadequate	24.6175	3.3678	405	1.5186	1.2323	17.9854	31.2495
	Adequate	75.3826	3.3678	405	1.5186	1.2323	68.7505	82.0146
Zinc-RDA-24 hour recall NPW	Inadequate	38.5911	4.1005	405	1.7629	1.3277	30.5163	46.6660
	Adequate	61.4089	4.1005	405	1.7629	1.3277	53.3341	69.4837
Vitamin A-24 hour recall NPW	Inadequate	50.9990	4.1613	405	1.7217	1.3121	42.8045	59.1935
	Adequate	49.0010	4.1613	405	1.7217	1.3121	40.8065	57.1955

MEN (age 15-54 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia MEN (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	12.7892	3.3751	238	1.4486	1.2036	6.1201	19.4584
	Normal	87.2108	3.3751	238	1.4486	1.2036	80.5416	93.8799
ID MEN (FER <15ug/L corrected for inflammation	Deficient	4.8712	1.7997	245	1.0432	1.0214	1.3154	8.4269
	Normal	95.1288	1.7997	245	1.0432	1.0214	91.5731	98.6846
WHO classification of BMI MEN	Thinness	25.3373	4.5248	270	1.5960	1.2633	16.3990	34.2756
	Normal	64.0361	5.0845	270	1.6553	1.2866	53.9923	74.0799
	Obese	10.6266	3.4623	270	1.8613	1.3643	3.7872	17.4660
Sickle cell genotype MEN	AA	93.2574	3.9459	224	3.4288	1.8517	85.4546	101.0602
	AS	6.7426	3.9459	224	3.4288	1.8517	-1.0602	14.5454
Thalassaemia MEN	Homo	3.0438	1.3622	210	0.8307	0.9114	0.3505	5.7370
	Other	96.9562	1.3622	210	0.8307	0.9114	94.2630	99.6495
Malaria status MEN	Positive							
	Negative	100	0	236	0.9639	981,762.0000	100	100
HIV results MEN	Positive	7.0325	6.8269	71	4.0505	4.0505	-6.7651	20.8301
	Negative	92.9675	6.8269	69	4.0505	2.0126	79.1699	106.7651

Appendix 11B: Sampling Errors for Urban areas of Kenya

Pre School Children (6-59 Months old)								
Variable	**Category**	**Estimate**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia PSC (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	24.8585	4.1924	827	2.2008	1.4835	16.5984	33.1187
	Normal	75.1415	4.1924	827	2.2008	1.4835	66.8813	83.4016
ID PSC (FER <15ug/L corrected for inflammation	Deficiency	22.6237	3.4532	918	1.7356	1.3174	15.8220	29.4248
	Normal	77.3763	3.4532	918	1.7356	1.3174	70.5752	84.1774
IDA PSC (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	12.3218	2.8059	827	1.7045	1.3056	6.7934	17.8502
	Normal	87.6782	2.8059	827	1.7045	1.3056	82.1497	93.2066
Vitamin A deficiency PSC (using RBP<0.70 µmol/L)	Severe	11.9652	3.1694	918	2.4297	1.5587	5.7231	18.2074
	Marginal	55.4867	5.2243	918	2.8155	1.6779	45.1973	65.7760
	Normal	32.5481	5.6745	918	3.7368	1.9331	21.3720	43.7240
Malaria status PSC	Positive	0.0000	0.0000	848	0.0000	0.0000	0.0000	0.0000
	Negative	100.0000	0.0000	848	3.1020	0.7613	100.0000	100.0000
HIV results PSC	Positive	1.4080	0.8425	903	1.2836	0.1329	-0.2513	3.0674
	Negative	98.5920	0.8425	886	1.2836	1.1329	96.9326	100.2513
Sickle cell genotype PSC	AA	89.4370	3.6746	876	3.3081	1.8188	82.1995	96.6744
	AS	10.2213	3.6646	876	3.3873	1.8405	3.0035	17.4391
	SS	0.3417	0.3446	876	0.8072	0.8984	-0.3370	1.0204
Thalassaemia PSC	Het	25.5030	7.2201	862	6.3266	2.5153	11.2825	39.7235
	Homo	2.5987	1.2441	862	1.4100	1.1874	0.1483	5.0491
	Normal	71.8983	7.1495	862	5.8334	2.4152	57.8160	85.9798
Tape_worm_qualitative PSC	Present	16.8958	4.9197	722	3.4641	1.8612	7.2015	26.5900
	Absent	83.1042	4.9197	722	3.4641	1.8612	73.4099	92.7985
Hookworm_qualitative PSC	Present	17.0851	4.9246	722	3.4405	1.8549	7.3810	26.7891
	Absent	82.9149	4.9246	722	3.4405	1.8549	73.2108	92.6190
Schistosoma_mansoni_qualitative PSC	Present	17.5479	4.9268	722	3.3715	1.8362	7.8395	27.2562
	Absent	82.4521	4.9268	722	3.3715	1.8362	72.7438	92.1604
Calcium-RDA-24 hour recall PSC	Inadequate	69.8583	6.5925	281	1.5681	1.2523	56.8585	82.8581
	Adequate	30.1417	6.5925	281	1.5681	1.2523	17.1418	43.1415
Iron-RDA-24 hour recall PSC	Inadequate	39.5855	6.6558	281	1.4073	1.1863	26.4609	52.7101
	Adequate	60.4145	6.6558	281	1.4073	1.1863	47.2898	73.5391
Zinc-RDA-24 hour recall PSC	Inadequate	44.2419	7.9853	281	1.9639	1.4014	28.4956	59.9881
	Adequate	55.7581	7.9853	281	1.9639	1.4014	40.0119	71.5044
Vitamin A-24 hour recall PSC	Inadequate	56.8599	8.3978	281	2.1843	1.4779	40.3002	73.4196
	Adequate	43.1401	8.3978	281	2.1843	1.4779	26.5804	59.6997
School Aged Children (5- 14 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia SAC (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	11.5002	2.6883	872	1.5714	1.2536	6.2020	16.7984
	Normal	88.4998	2.6883	872	1.5714	1.2536	83.2016	93.7980
ID SAC (FER <15ug/L corrected for inflammation	Deficiency	7.6485	2.3173	942	1.8814	1.3716	3.0828	12.2143
	Normal	92.3515	2.3173	942	1.8814	1.3716	87.7857	96.9172

IDA SAC (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	3.8257	1.5138	872	1.3784	1.1741	0.8422	6.8092
	Normal	96.1743	1.5138	872	1.3784	1.1741	93.1908	99.1578
Vitamin A deficiency SAC (using RBP<0.70 µmol/L)	Severe	3.7012	1.3900	942	1.3414	1.1582	0.9626	6.4398
	Marginal	40.6442	6.7938	942	4.7346	2.1759	27.2587	54.0297
	Normal	55.6547	6.9555	942	4.8510	2.2025	41.9506	69.3588
Malaria status SAC	Positive	0.7535	0.6039	908	1.1636	1.0787	-0.4365	1.9436
	Negative	99.2465	0.6039	908	1.1636	1.0787	98.0564	100.4365
HIV results SAC	Positive	0.4957	0.4275	981	0.9634	0.9815	-0.3466	1.3380
	Negative	99.5043	0.4275	981	0.9634	0.9815	98.6619	100.3466
Sickle cell genotype SAC	AA	95.6827	1.6004	904	1.4739	1.2141	92.5294	98.8360
	AS	4.3173	1.6004	904	1.4739	1.2141	1.1640	7.4706
Thalassaemia SAC	Het	24.8139	6.4877	878	5.2054	2.2815	12.0302	37.5977
	Homo	4.1760	1.7458	878	1.7573	1.3256	0.7360	7.6161
	Normal	71.0100	6.6228	878	4.9161	2.2172	57.9601	84.0600
Pregnant Women (Age 15 -49 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia PW (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	29.3705	8.9408	104	1.6515	1.2851	11.5707	47.1702
	Normal	70.6295	8.9408	104	1.6515	1.2851	52.8298	88.4293
ID (FER <15ug/L corrected for inflammation) - PW	Deficiency	20.3802	7.5338	111	1.4979	1.2239	5.3958	35.3645
	Normal	79.6198	7.5338	111	1.4979	1.2239	64.6355	94.6042
IDA PW (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	10.4534	4.2210	104	0.8158	0.9032	2.0500	18.8569
	Normal	89.5466	4.2210	104	0.8158	0.9032	81.1431	97.9500
Vitamin A deficiency PW (using RBP<0.70 µmol/L)	Severe	12.9889	#	111	4.3429	2.0840	-8.3047	34.2824
	Marginal	31.2068	9.8025	111	1.9167	1.3845	11.7101	50.7036
	Normal	55.8043	11.4439	111	2.2739	1.5080	33.0429	78.5658
Malaria status PW	Positive	0	0	110	0	0	0	0
	Negative	100	0	110	1.1469	1.0710	100	100
HIV results PW	Positive	2.2299	2.2228	119	1.0059	1.0029	-2.1866	6.6465
	Negative	97.7701	2.2228	118	1.0059	1.0029	93.3535	102.1866
Sickle cell genotype PW	AA	100	0	113	0	0	0	0
	AS	0	0	113	0	0	0	0
Thalassaemia PW	Het	25.5894	8.9423	109	1.5427	1.2420	7.8126	43.3662
	Homo	1.1329	1.1689	109	0.4482	0.6694	-1.1909	3.4566
	Normal	73.2777	9.0063	109	1.5217	1.2336	55.3737	91.1817
Tape_worm_qualitative PW	Present	14.2610	9.4903	76	2.0177	1.4204	-4.7099	33.2310
	Absent	85.7390	9.4903	76	2.0177	1.4204	66.7681	104.7099
Hookworm_qualitative PW	Present	13.5486	9.4139	76	2.0725	1.4396	-5.2695	32.3660
	Absent	86.4514	9.4139	76	2.0725	1.4396	67.6334	105.2695
Schistosoma_mansoni_qualitative PW	Present	13.5486	9.4139	76	2.0725	1.4396	-5.2695	32.3660
	Absent	86.4514	9.4139	76	2.0725	1.4396	67.6334	105.2695
Calcium-RDA-24 hour recall PW	Inadequate	96.3489	3.8994	39	0.4849	0.6964	88.4405	104.2573
	Adequate	3.6511	3.8994	39	0.4849	0.6964	-4.2573	11.5595

Iron-RDA-24 hour recallNPW	Inadequate	100		39				
	Adequate			39				
Zinc-RDA-24 hour recall PW	Inadequate	93.5234	5.0815	39	0.4783	0.6916	83.2177	103.8292
	Adequate	6.4766	5.0815	39	0.4783	0.6916	-3.8292	16.7823
Vitamin A-24 hour recall PW	Inadequate	69.1729	17.4663	39	1.6051	1.2669	33.7495	104.5963
	Adequate	30.8271	17.4663	39	1.6051	1.2669	-4.5963	66.2504
Non-pregnant Women (Age 15 -49 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia NPW (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	17.2866	3.7564	592	2.1816	1.4770	9.8866	24.6865
	Normal	82.7134	3.7564	592	2.1816	1.4770	75.3135	90.1134
ID NPW (FER <15ug/L corrected for inflammation	Deficiency	21.3288	4.0660	+	2.3160	1.5219	13.3215	29.3361
	Normal	78.6712	4.0660	631	2.3160	1.5219	70.6639	86.6785
IDA NPW (Haemoglobin <12.0g/dL and FER <15ug/L	IDA	12.3928	3.4034	592	2.3585	1.5357	5.6883	19.0973
	Normal	87.6072	3.4034	592	2.3585	1.5357	80.9027	94.3117
Vitamin A deficiency NPW (using RBP<0.70 µmol/L)	Severe	0.2512	0.1813	631	0.3083	0.5553	-0.1058	0.6081
	Marginal	8.1301	2.6634	631	2.2325	1.4942	2.8849	13.3752
	Normal	91.6188	2.6858	631	2.2082	1.4860	86.3295	96.9080
Malaria status NPW	Positive	2.1732	1.0550	606	1.2905	1.1360	0.0958	4.2507
	Negative	97.8268	1.0550	606	1.2905	1.1360	95.7493	99.9042
HIV results NPW	Positive	0.0000	0.0000	660	0.0000	0.0000	0.0000	0.0000
	Negative	100.0000	0.0000	639	3.0976	1.7600	100.0000	100.0000
Sickle cell genotype NPW	AA	87.5328	3.8521	602	3.0568	1.7484	79.9455	95.1201
	AS	12.4672	3.8521	574	3.0568	1.7484	4.8799	20.0545
Thalassaemia NPW	Het	20.8262	5.4650	581	3.9296	1.9823	10.0612	31.5912
	Homo	7.6312	4.0373	581	5.0167	2.2398	-0.3215	15.5830
	Normal	71.5426	5.6610	581	3.4149	1.8480	60.3915	82.6937
Tape_worm_qualitative NPW	Present	11.5752	3.6063	453	2.1171	1.4550	4.4662	18.6841
	Absent	88.4249	3.6063	453	2.1171	1.4550	81.3159	95.5338
Hookworm_qualitative NPW	Present	11.9457	3.6366	453	2.0949	1.4474	4.7770	19.1143
	Absent	88.0544	3.6366	453	2.0949	1.4474	80.8857	95.2231
Schistosoma_mansoni_qualitativ NPW	Present	12.3632	3.7285	453	2.1379	1.4622	5.0132	19.7131
	Absent	87.6368	3.7285	453	2.1379	1.4622	80.2869	94.9868
Calcium-RDA-24 hour recall NPW	Inadequate	96.3666	1.6273	405	1.1764	1.0846	93.1619	99.5712
	Adequate	3.6335	1.6273	405	1.1764	1.0846	0.4288	6.8381
Iron-RDA-24 hour recall NPW	Inadequate	27.5804	6.0167	405	2.8190	1.6790	15.7321	39.4287
	Adequate	72.4196	6.0167	405	2.8190	1.6790	60.5713	84.2679
Zinc-RDA-24 hour recall NPW	Inadequate	48.2184	5.7318	405	2.0466	1.4306	36.9312	59.5056
	Adequate	51.7816	5.7318	405	2.0466	1.4306	40.4944	63.0689
Vitamin A-24 hour recall NPW	Inadequate	45.1477	5.6012	405	1.9704	1.4037	34.1177	56.1777
	Adequate	54.8523	5.6012	405	1.9704	1.4037	43.8223	65.8824

MEN (age 15-54 years)								
Variable	**Category**	**Mean**	**Std Err**	**N W**	**DEFF**	**DEFT**	**95% CI**	
Anaemia MEN (Haemoglobin <12.0g/dL adjusted for altitude and corrected for inflammation)	Anaemic	5.1765	2.4288	238	1.1436	1.0694	0.3771	9.9759
	Normal	94.8235	2.4288	238	1.1436	1.0694	90.0241	99.6229
ID MEN (FER <15ug/L corrected for inflammation	Deficient	1.6317	1.3179	245	1.0253	1.0126	-0.9720	4.2353
	Normal	98.3683	1.3179	245	1.0253	1.0126	95.7646	100.9720
WHO classification of BMI MEN	Thinness	7.8204	3.3593	270	1.9026	1.3794	1.1844	14.4564
	Normal	83.7251	5.0922	270	2.3128	1.5208	73.6661	93.7842
	Obese	8.4545	3.5123	270	1.9372	1.3918	1.5163	15.3927
Sickle cell genotype MEN	AA	96.9868	2.7087	224	2.1223	1.4568	91.6305	102.3431
	AS	3.0132	2.7087	224	2.1223	1.4568	-2.3431	8.3695
Thalassaemia MEN	Homo	2.7708	2.2167	210	1.5299	1.2369	-1.6119	7.1535
	Other	97.2292	2.2167	210	1.5299	1.2369	92.8465	101.6119
Malaria status MEN	Positive			236				
	Negative	100	0	236	3.3377	0.8269	100	100
HIV results MEN	Positive	1.9366	2.0654	71	0.2960	0.2960	-2.2377	6.1110
	Negative	98.0634	2.0654	69	0.2960	0.5441	93.8890	102.2377

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