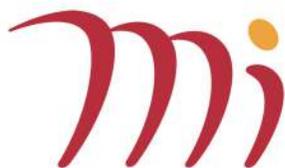# Indicators and Methods for Cross-Sectional Surveys of Vitamin and Mineral Status of Populations

Micronutrient Initiative

and the

Centers for Disease Control and Prevention

Forward

Vitamin and mineral deficiencies remain a significant public health problem in many parts of the world, particularly in developing countries where deficiencies to vitamin A, iron, iodine and other micronutrients leads to adverse health consequences. These include diminished learning and development capacity of young children and reduced work capacity of adults, both of which contribute to poor socioeconomic condition of populations. The implementation of effective intervention programs to eliminate or reduce the prevalence of vitamin and mineral deficiencies in populations requires a wide array of activities directed towards ensuring high coverage of interventions. One component of national micronutrient programs includes the periodic assessment of the status of vitamin and mineral deficiencies, as well as the adequacy of the coverage of interventions in a population using cross-sectional surveys.

Periodic cross-sectional surveys are helpful in answering questions such as: What is the current magnitude and distribution of selected vitamin and mineral deficiencies? Has the prevalence of disease changed over time in comparison with previous surveys? What is the coverage of interventions, such as the proportion of target populations who have received nutrient supplements or are consuming fortified foods? Has coverage changed over time? Are there groups in the population where the prevalence of vitamin and mineral nutrient deficiencies remains high or where the coverage of interventions is inadequate? Results from surveys also provide information on whether intervention strategies are helping to achieve program objectives. For example, if there are interventions directed to the population to promote behavioral change to overcome vitamin and mineral deficiencies, then the level of knowledge, attitudes, and practices (KAP) of the population can be assessed using periodic surveys. The results of a cross-sectional survey provide a snapshot of the vitamin and mineral status of a population at a specific time period.

We hope you find this manual useful in the planning and implementation of cross-sectional surveys and trust that the information generated from such surveys will help to support programs to prevent and control vitamin and mineral deficiencies.

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Disclaimer

The mention of product names and websites in this document do not constitute an official endorsement for the products by any of the agencies or individuals involved in the development of this manual. They are mentioned to provide users of this manual with information on the types of products frequently used in micronutrient surveys and where to obtain further information. None of the authors, reviewers, or agencies has a monetary link to the private companies mentioned.

Abbreviations

AGP	Alpha 1-acid glycoprotein
APP	Acute Phase Proteins
ARI	Acute Respiratory Infection
CDC	Centers for Disease Control and Prevention, Atlanta, USA
CRP	C-Reactive Protein
d	Level of absolute precision
DBS	Dried blood spot
DEFF	Design Effect
DHS	Demographic and Health Survey
EDTA	Ethylenediaminetetraacetic acid
EPI	Expanded Programme on Immunization
Hb	Hemoglobin
HH	Household
HKI	Helen Keller International
HPLC	High-Pressure Liquid Chromatography
ICCIDD	International Council for the Control of Iodine Deficiency Disorders
ID	Iron Deficiency
IDA	Iron Deficiency Anemia
IDD	Iodine Deficiency Disorders
ILSI	International Life Science Institute
IMMPaCt	International Micronutrient Malnutrition Prevention and Control Program, CDC
INACG	International Nutritional Anemia Consultative Group
IVACG	International Vitamin A Consultative Group
KAP	Knowledge, Attitudes, and Practices
MAPit	Micronutrient Action Plan instructional tool
MICS	Multiple Indicator Cluster Survey
MI	Micronutrient Initiative
MM	Micronutrient Malnutrition
PATH	Program for Technology in Health
PDAs	Personal Digital Assistants
ppm	Parts Per Million
PPS	Probability Proportionate to Size
PSU	Primary Sampling Unit
RBP	Retinol Binding Protein
SF	Serum Ferritin
TfR	Transferrin Receptor
TSH	Thyroid Stimulating Hormone (or thyrotropin)
UI	Urinary iodine
UNICEF	United Nations Children's Fund
USI	Universal Salt Iodization
VAD	Vitamin A Deficiency
WHO	World Health Organization
WRA	Women of Reproductive Age
WSC	World Summit for Children
Z	Z-score

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Chapter 1
Overview

1.1   Introduction

This manual is intended for program managers who are responsible for the design and implementation of surveys to assess vitamin and mineral deficiencies (see Box 1.1) as well as others involved in the planning, implementation, analysis, and reporting of survey results. Such surveys are usually carried out periodically to provide information that should lead to advocacy and appropriate intervention strategies. When carried out sequentially, surveys can be used to track progress of prevention and control efforts over time.

Box 1.1 The main objective of this manual is to describe procedures and tools necessary to undertake a cross-sectional survey that will:

- Provide estimates of the prevalence of iron deficiency anemia, iodine deficiency, and vitamin A deficiency.

- Provide information on the coverage of prevention and control programs such as vitamin A capsule distribution, salt iodization, and flour fortification.

1.2   Public Health Significance of Vitamin and Mineral Deficiencies

Many vitamins and minerals are needed in small amounts to perform important physiological functions. [1] Iron, vitamin A, and iodine are three major micronutrients targeted for intervention in many countries to reduce the prevalence of these deficiencies, and therefore, improve the health and socioeconomic status of populations. A description of the magnitude and consequences of these deficiencies is provided in Appendix 1. There are a number of other important vitamins and minerals of public health importance not covered in this manual, including folate and zinc.

Unlike some infectious diseases that may be eradicated, such as smallpox or polio, vitamin and mineral deficiencies can only be eliminated and controlled through ongoing programs to ensure adequate nutrient intake among populations. While insufficient dietary intake is the primary cause of nutrient

deficiencies, other conditions, such as infectious and parasitic diseases, chronic illness, certain genetic conditions, and other dietary components that may enhance or interfere with nutrient absorption, also affect vitamin and mineral status.

1.3   Assessing Multiple Vitamin and Mineral Deficiencies

In order to develop appropriate intervention strategies and plan effective control programs, it is useful to have information regarding the magnitude, distribution, and etiology of several different vitamin and mineral deficiencies.   In developing countries, populations are often affected by multiple nutrient deficiencies, frequently as a result of poverty and diets with little diversity.   This manual is intended to provide a framework for the design and implementation of national surveys that allow countries to simultaneously assess iron, vitamin A, and iodine deficiencies.

1.4   Planning the Survey

Designing an integrated micronutrient survey requires many decisions, and these will be dependent on the survey objectives, resources available, and the time period in which the survey is to be completed (Box 1.2).   In all cases, it is essential that the data collected can provide information to guide intervention strategies and programs.

It may be instructive to consider the steps in Box 1.2 in reverse order, where it is ultimately the use of data for planning and improving interventions that should be the driving force behind the design of the survey.   Only relevant data should be collected that may affect program management, with emphasis placed on collecting data with good quality and rigor.   The level to which survey results can help advocate for intervention programs, guide on-going prevention and control programs, and lead to effective strategies will justify the expense of the survey in the first place.   In planning a survey, it is important to review the overall survey steps listed in Box 1.2 several times before a final plan is agreed upon.

We recommend that a national survey planning committee be created and include relevant government agencies and other organizations.   A collaborative effort on the support, design, and implementation of the survey assists in assuring the results of the survey are accepted and endorsed by the various organizations.

Box 1.2. Issues and steps in designing and implementing surveys and the chapters where this information can be found.

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Chapter 2
Overall Survey Objectives

This chapter discusses the development of survey objectives, such as which nutrients to include, which indicators to use, and which target groups to assess. These overall objectives should be decided upon based on the utility of the information and cost of obtaining the information. The overall objectives influence subsequent aspects of the survey, such as the sample size, laboratory assays, questionnaire design, field logistics, etc.

2.1 Which Nutrients to Include?

In many developing countries, the majority of the population is affected, to some extent, with iron, vitamin A, and iodine deficiencies. Thus, a survey might include indicators to estimate the prevalence of all three deficiencies, the prevalence of conditions that contribute to the deficiencies, coverage of interventions and the populations' related knowledge, attitudes, and practices (KAP). Issues that might affect the decision on which three nutrients to assess are presented in Box 2.1.

Box 2.1 Issues concerning which vitamins and minerals to include in a survey can be influenced by the following:

- ❖ What is already known about different vitamin and mineral deficiencies in the country?
- ❖ Has there been a recent survey of any of the nutrients?
- ❖ Is an intervention program in place or being planned?
- ❖ Will it be feasible to test the same target groups in the survey for more than one micronutrient?

2.2 Which Indicators to Measure?

The survey will most likely include the collection of data relevant to the prevention program and impact indicators, i.e., assessment of intervention coverage, and measurement of nutrient status. This would allow relevant authorities in the public and private sectors to determine which interventions appear to be appropriate and whether implementation strategies and components currently in place are adequate. In

addition, it is generally useful to collect data on other relevant health parameters, demographic and socioeconomic characteristics of the survey population, and knowledge, attitudes, and practices related to intervention programs. Through analyses of these variables it may be possible to better understand the major factors associated with the nutrient deficiencies, characteristics of groups targeted for intervention, and in turn, identify opportunities for improved program planning. An important aspect of the survey management is to focus on collection of <u>only</u> essential data related to the overall survey objectives.

This manual emphasizes the use of indicators recommended by WHO and other internationally recognized organizations (see Table 2.1) for use in population surveys for classifying the public health significance of vitamin and mineral deficiencies and monitoring progress toward their elimination. Other indicators may be useful for special research studies, but are often less suitable in large cross-sectional surveys. Appendix 2 presents detailed information on different indicators along with the survey requirements for their measurement. Appendix 2 also includes a section on assessing infection or inflammation status which can affect the results of a number of laboratory tests of vitamin and mineral status. Different indicators have logistical requirements in terms of equipment, technology, human resource capacity, and laboratory expertise.

2.2.1 General Issues Related to Indicator Selection

This section presents some general issues related to the selection of indicators for a micronutrient survey. A general overview of some of the information that might be collected in a cross-sectional survey is provided in Box 2.2. The issues include collection, processing, storage, transport and testing of blood and urine specimens (see Table 2.1), assessment of coverage of supplements and food fortification programs, and decisions on selecting target groups. These indicators are described in more detail in Appendix 2.

Box 2.2 The basic components of a vitamin and mineral status survey may include:

- Information on demographic characteristics of the survey population
- Information relating to intervention programs (fortification, supplementation, communication and promotion)
- Testing of samples of fortified foods and/or related labelling information
- Collection and testing of blood and urine specimens to assess vitamin and mineral status
- Collection of other specimens and/or questionnaire data on illness and infection that could affect laboratory test results
- Collection of limited dietary data (usually a simple food frequency questionnaire)

Table 2.1 Overview of selected indicators to assess iron, iodine and vitamin A status and intervention programs.

Nutrient	Indicators for Assessing Status	Indicators for Assessing Interventions		
		Supplementation	**Fortification**	**Dietary Improvement**
Iron	Hemoglobin Serum ferritin Transferrin receptor	% coverage and compliance with iron supplements/ multiple vitamins in target groups	% households using iron-fortified products (e.g., iron-fortified flour); % households using in-home fortification (e.g., Sprinkles)	% target population regularly consuming iron-fortified foods, iron-rich foods, foods which promote iron absorption, and/or foods that inhibit iron absorption
Iodine	Urinary iodine	% coverage and compliance with multiple vitamins containing iodine in target groups	% households using iodine-fortified products (e.g., iodized salt)	% target population regularly using iodine-fortified foods
Vitamin A	Serum retinol	% coverage of vitamin A supplements/multiple vitamins in target groups	% households using vitamin A fortified foods (e.g. fortified oil, sugar, dairy) % households using in-home fortification (e.g., Sprinkles)	% target population regularly eating vitamin A rich foods

2.2.1.i   Blood Specimen Collection

Blood and/or resulting serum samples are often collected to assess the iron and/or vitamin A status of populations. Specimens can be collected using either capillary or venous blood depending on the volume of blood needed for laboratory testing (see Table 2.2). For a number of laboratory tests, small volumes of whole capillary blood obtained from a finger puncture can be tested immediately (e.g., Hb using HemoCue™) or spotted onto filter paper. It is also possible to collect capillary blood samples in microtainers for further processing and testing. For laboratory assays which require a large volume of serum (> 400μl), collection of blood via venipuncture would be necessary.

Table 2.2. Blood specimen collection method and device, and specimen type

Source of Blood	Collection Method	Collection device or secondary use of specimen	Specimen type
Capillary	Finger puncture	Microcuvette for Hemocue	Whole blood
		DBS on filter paper	Whole blood
		Microtainer with no anti-coagulant or serum separator	Serum
		Microtainer with Heparin, EDTA or Na	Plasma
Venous	Venipuncture	Microcuvette for Hemocue	Whole blood
		DBS on filter paper	Whole blood
		Vacutainer (with serum separator)	Serum
		Vacutainer with Heparin, EDTA or Na	Plasma

DBS=dried blood spot; EDTA=ethylenediaminetetraacetic acid, an anticoagulant; Na=sodium

If less than 400 μL of whole blood is required then capillary blood from a finger puncture is an option. As stated previously, capillary blood may be collected into microcuvettes directly from the finger when testing Hb using the HemoCue or other similar systems. Capillary blood may also be collected into anti-coagulant-containing tubes such as the Becton Dickinson Microtainer® or the Sarstedt Microvette®. These small tubes can contain different volumes, primarily in the 200-600 μL range. Blood from these tubes can then be tested for Hb in the field after collection. Alternatively, anti-coagulant tubes of blood could be kept cool and out of direct sunlight, taken to a central location and tested for Hb *within eight hours*. In a central location, blood from the microtainers could also be spotted onto filter paper or, if microtainers with no anti-coagulants are used, can be processed in order to separate the serum fraction, which can then be prepared for storage and transport.

Disposable, single-use, trigger-type lancets should be used to perform finger punctures for capillary blood collection. Lancets are available with different blade widths and depths. The more blood needed, the greater depth and/or blade width lancets should be used. Care needs to be taken to select the appropriate lancet for each target group, e.g., lancets for preschool children are of smaller gauge needle and less depth than lancets for adults.

Survey staff with or without phlebotomy experience can be trained to collect capillary blood samples. However, it is essential that experienced trainers conduct the training and assure standardized techniques.

The costs of testing different biological indicators of micronutrient status vary considerably depending on the assay and type of specimen collected (e.g., whole blood, serum/plasma, or dried blood/dried serum spot). It is essential to involve laboratory personnel with experience in conducting population-based nutrition surveys early in the planning phase to provide advice and guidance on

biochemical methods. Issues concerning supplies, procedures for collection, processing, transport/shipping, storage, and analysis of laboratory specimens must be considered. The following issues should be considered:

- What type(s) of specimen(s) should be collected?
- What volume is required?
- What supplies are needed to collect the biological specimens?
- What kind of training is required for laboratory field staff?
- At what temperature must the specimens be stored?
- How will waste products, such as lancets, needles, syringes, be safely disposed?

It is important to identify, as soon as possible, a laboratory that would perform the tests and verify that the laboratory has adequate equipment, experience, and quality assurance mechanisms in place. Some of the issues to be agreed upon with the testing laboratory include the number and volume of samples that could be tested in a timely manner, how the samples are to be processed, stored, and transported to the laboratory, and assay costs. Another issue is how the results of the laboratory tests will be provided; generally an electronic file with the laboratory results is preferred. Each test result should include the survey participant's ID number as assigned in the survey. In addition, information concerning the laboratory methods used and any quality assurance from the testing should be requested in advance. It is preferable that a single laboratory performs analysis of all samples for a specific assay to avoid inter-laboratory variation.

2.2.1.ii   Assessing coverage of supplementation interventions

There are a number of issues in attempting to obtain information to estimate accurate supplement coverage. For vitamin and mineral deficiencies, for many countries, most commonly this would include iron and vitamin A supplementation. For vitamin A supplementation, in some areas, the provision of a supplement to an individual is not documented in medical records or on a personal health record, while in other areas vitamin A supplementation is recorded on an immunization record or other medical record. Usually questions concerning vitamin A supplement use in children are limited to the previous 6 months. In areas where vitamin A supplements are not documented in an immunization or medical record, during the interview, respondents are asked whether they or their child have received supplements, which may be enhanced by showing an example of the capsule or by associating the supplement with the place or event of delivery. The history based on recall may not be accurate for a number of reasons which could

potentially over- or under-estimate coverage depending on the situation. We recommend that questions concerning supplement coverage need to be tailored to each country's situation to maximize validity.

2.2.1.iii Assessing adequacy and coverage of fortification interventions

In assessing the use of fortified foods in the household, the inspection of food packaging can be useful to determine if the product is labeled as fortified. In some instances, the packaging may not be available. For some fortified products, there may be a simple test that can be performed in the field, such as the rapid test kit to semi-quantitatively estimate the iodine content in salt. Some iodine rapid test kits are of low sensitivity and specificity compared to more definitive laboratory tests. Another issue is whether a sample of the food should be collected and sent to a laboratory for testing, an issue that needs to be addressed early in the planning stage of a survey to determine the test(s) to be performed as well as issues related to collection, labeling, storing, and shipping of food specimens, and identification of appropriate laboratories. Should it be determined that salt will be collected from households (or other sources) and sent to a central laboratory for quantifying the level of iodine in salt, we recommend the salt titration method or use of the WYD Iodine Checker (National Salt Research Center, Tianjin, China).

2.3 Which Target Groups to Assess?

An important consideration in the selection of indicators for a micronutrient survey is to determine which groups to assess which is usually based on *vulnerability*, *representativeness*, and *accessibility*[2], or, to assess the coverage or effectiveness of an intervention targeted to a specific group, such as vitamin A supplementation in young children or iron supplementation in a specific group of women. The group selected should be vulnerable to the deficiency, have measurable negative health consequences as a result of the deficiency, and be responsive to interventions. Representativeness is the extent to which the selected group represents the status of the general population and/or other potential target groups. Accessibility has to do with logistics and the ability to gather data in a systematic way that reduces costs in performing the survey. Finally, it may be important to take into account whether a group is useful for assessing multiple micronutrient problems since this could greatly increase the efficiency of a survey. The following presents the groups usually assessed for micronutrient status and coverage in cross-sectional surveys, although other groups can be assessed depending on the situation:

- Iron deficiency anemia: women of childbearing age and/or preschool children
- Vitamin A deficiency: preschool children

- Iodine deficiency: school-age children and/or women of childbearing age

2.3.1 Preschool children

Preschool children, usually defined as less than five years of age, are particularly vulnerable to the consequences of micronutrient malnutrition and are an important target group to assess for some micronutrient deficiencies. Iron and vitamin A deficiencies are often prevalent among preschool children in developing countries. Although preschool children are also vulnerable to iodine deficiency, this age group is generally *not* recommended as a target group for assessing iodine deficiency primarily because it is difficult to collect urine samples in this age group Preschool children may be accessed either through household-based surveys, or where clinic registration and attendance is high, through clinic-based surveys.

2.3.2 School age children

Historically, school age children between 6 and 12 years of age have been targeted for surveys of iodine deficiency primarily because of the relative ease with which they could be assembled to assess goiter. However, because the developing fetus is the most vulnerable to the negative consequences of iodine deficiency, it may be important to assess iodine status of women of reproductive age. We would like to note that at the present time there are no cut off values for urinary iodine in nonpregnant women by WHO, although some experts have provided such values.

Although school age children can be efficiently assessed for iodine deficiency in schools, school-based surveys should only be implemented in areas where the proportion of children attending school is high (around 75% or higher). In populations with low school attendance, a household-based survey would be preferable. There are other reasons to assess school age children, such as for micronutrient supplement coverage or impact if they are targeted to this group, or for assessing the causes of anemia, in addition iron deficiency, in this group, such as hookworm. The assessment of VAD in school age children is infrequent.

2.3.3 Women of reproductive age

Women of reproductive age (WRA), usually defined as women 15 through 49 years of age, are also vulnerable to vitamin and mineral deficiencies and may provide insight into the magnitude of micronutrient deficiencies among newborns. In countries where vitamin A deficiency is endemic, pregnant women often experience ocular symptoms of VAD, such as night blindness, which continue into the early period of lactation. In some countries of South-East Asia, the prevalence of night blindness has been reported to be greater than 10% in pregnant women.[3] For nursing infants, breast milk from deficient mothers is likely to contain insufficient levels of vitamin A to build or maintain vitamin A stores.

In pregnant women, iron deficiency leads to anemia which is associated with an increased risk of maternal mortality and morbidity, fetal morbidity and mortality, and intrauterine growth retardation. The consequences of iodine deficiency in pregnant women are particularly severe since thyroid hormones are essential for the mental and physical development of the fetus. Brain damage in the fetus and infancy attributable to severe and prolonged iodine deficiency is likely to be irreversible.[9] However, in many populations, finding an adequate number of pregnant women in household-based surveys is too time-consuming because a large number of households would need to be visited to identify a sufficient sample of pregnant woman. Therefore, for household-based micronutrient surveys in populations with low fertility rates, in general it is not recommended to have pregnant women as one of the main target groups. It may be possible to assess pregnant women in a clinic-based survey; however, similar to the issue in school-based surveys, it would be important to assure a large proportion of the pregnant women seeking prenatal care from clinics.

2.3.4 Men

While men can suffer the consequences of vitamin and mineral deficiencies, they tend to be less affected compared to preschool children and women. In some settings, men might be assessed to determine their level of knowledge, attitudes, and practices towards vitamin and mineral deficiencies as well as their role, in some populations, in determining which foods to purchase. Men may also be assessed for haemoglobin in some settings to estimate the role of iron deficiency as a cause of anemia in women and children. The rationale behind this is that when the prevalence of anemia is high in women and children but low in men, then iron deficiency is likely to be a major contributor to the high prevalence of anemia in the women and children. If the prevalence of anemia is high in all three groups, then causes of anemia other than iron deficiency are likely to be prevalent, such as malaria or other parasitic infections.

2.4   Summary on target groups and survey sites

The selection of age groups to asses depends on a number of factors as discussed previously. Table 2.3 summarizes the usual target groups by micronutrients based on a balance of accessibility and vulnerability. It is always important to consider which age groups will be targeted for interventions as data collected can provide useful baseline data or evidence of impact of these interventions.   Preschool children and women of reproductive age are generally targeted for interventions. An important issue when determining which target group to include in a survey depends on the survey site, household vs. clinic-based vs. school-based. If a household survey is to be performed, then some of the target groups in Table 2.3 may feasible. For example, if consideration is being given to assessing pregnant women in a household-based survey, the planning team must take into account that this would dramatically increase the number of households to be visited. Also, for school children and men, a household-based survey would need to be scheduled when these groups would most likely be available at the household. Table 2.4 provides an overview of contact points for different age groups to be included in a survey. More details on the survey site are presented in Chapter 3 but this topic is mentioned here because it does affect decisions on selecting target groups.

Table 2.3 Recommended age and sex groups for assessments

Micronutrient deficiency and Indicator	Preschool children	School-age children	Women of reproductive age		Men
			Not Pregnant	Pregnant	
VAD (Serum retinol)	1	-	2	2	-
ID and Anemia (Hb, serum ferritin, TfR)	1	1	1	1*	1*
IDD (Urinary iodine)	-	1	2	1	-

1 = the indicator is recommended by WHO expert group and cutoff values are available
2 = either not directly recommended by WHO expert group and/or cutoff values have not been established; however, other expert groups, institutions, or experts may have recommended the group and/or cutoff values
- = no WHO expert group recommendations on the group with the specific indicator
*There are cutoff values for anemia in these groups by a WHO expert group but no cutoff values for serum ferritin or TfR

2.5   Where to measure participants - household or a central site?

Should individuals be interviewed and have biologic specimens collected in the household or invited to a central location within the cluster (such as the health clinic) for the survey? The advantages of surveying individuals at a central site is that all the equipment, such as length boards, scales, and blood collection

aspects, could be set up once in the cluster. This makes data collection much faster. However, in some situations there may not be a convenient central site or it may be inconvenient for the participants to get to a central site. It may be difficult for ill individuals or those with certain types of disabilities or chronic diseases to travel to a central site.

Table 2.4 Target groups to assess and possible survey sites

Group(s) to Assess	Possible survey sites
Preschool children *and/or* women of reproductive age	• Assess preschool children and women in a household-based survey • Assess preschool children and women at a public health clinics if clinic enrollment/registration is high
School-age children only	• Household-based if school enrollment low, e.g., <75%, or school not in session • School-based if enrollment high, e.g., >75% for both males and females and school is in session during survey
Preschool children *and* women of reproductive age *and* school-age children	• Assess preschool children and women in a household-based survey or, if appropriate, a clinic-based survey, and assess school children in schools if school enrollment high and school in session during the survey • Assess all three groups in a household-based survey

2.6   Benefits of survey to participants

In general, it is discouraged to provide survey participants with monetary compensation for participation in surveys or to provide medications or treatments. In some surveys the teams may provide a small gift to the household (such as iodized salt) or candy or toy for a child. Should any medical conditions be identified during the survey, such as severe anemia, the participant should be informed of this finding, provided written information on the condition, and referred to a local health facility. If laboratory tests are to be performed, such as serum retinol or urinary iodine, the participant should be told that these tests will not be analyzed until a later date and, in many countries, it would not be possible to inform the participant of the results of the laboratory tests.

Chapter 3
Survey Design and Sampling Strategies

3.1 Introduction

Some of the details of designing a cross-sectional survey and sampling strategies are discussed in this Chapter. The survey design is based on the overall survey objectives which define:

- Indicators to be assessed
- Target groups to be surveyed
- Where subjects are recruited, the survey site (e.g., in households, health clinics, or schools)

Cross-sectional surveys are useful in providing an overall estimate of prevalence and coverage in a geographic area. They are not useful in identifying "pockets" of disease or low coverage. There are other methods more suitable to identifying "pockets", such as lot quality assurance methods (see *Monitoring Universal Salt Iodization Programmes*[4] for examples relating to iodized salt). Issues in the design of the survey discussed in this Chapter are:

- National vs. sub-national estimates
- Whether the survey is household, clinic, or school-based
- Implementing an independent vitamin and mineral deficiency survey or incorporating a micronutrient component into another planned survey
- Sample size
- Number of clusters to select
- How to select clusters

Some of the basic issues and terminology used in sampling are presented in Appendix 4 and it is recommended that those unfamiliar with basic sampling theory review this appendix prior to reading the next sections in this chapter.

3.2 National vs. Sub-National Estimates

If a national estimate is needed, an important decision is whether the survey will be conducted to provide a single estimate for the entire country *or* if there is also a need to provide separate estimates for sub-national areas, referred to as "strata." For each stratum for which an estimate is desired, such as a province or region, a separate survey sample would need to be drawn and therefore expense and time requirements are directly proportional to the number of strata in the survey. (Note that there could be a trade off such as accepting a lower level of precision for each stratum.) Deciding on the number of strata to sample should be based on at least the following two factors:

1. Interventions are stratum-specific, i.e., they are implemented in certain areas of a country or based on specific population subgroups.
2. Interventions or actions may be directed to stratum-specific administrative levels where important differences in the etiology and magnitude of problems need to be identified.

If the country is divided into sub-national areas and a separate cluster survey performed in each area, this is referred to as a *stratified cluster survey*.[5] Estimates from each of the sub-national areas can be combined to produce an overall national estimate (see section on weighting in Chapter 6). There is a possibility of over-interpretation of survey results when a single cluster survey is performed at the national level and then sub-national estimates are derived based on relatively few clusters (see Section 3.6). For example, if a single 30-cluster survey is performed at the national level, and four clusters were located in one province, the estimate for that province would most likely be very imprecise, which could be seen by including confidence limits around the estimates.

In some surveys the goal may not be to derive a national estimate but to perform a survey in one specific area of the country, i.e., a target area. A decision would need to be made whether a single survey is needed for the target area vs. the need to stratify within that target area.

3.3 Household vs. clinic vs. school-based surveys

Most of this chapter will present information on how to perform household-based surveys, which are the most common type of national cross-sectional survey. In some countries there may be an opportunity to perform a national survey in a clinic population (assuming high clinic coverage/registration) or school population (assuming high school attendance). At the first stage of selection, in household-based surveys,

the cluster is the enumeration unit or community selected to be surveyed; in clinic-based surveys, the clusters are clinics selected for the survey; and in school-based surveys, the selected schools are the clusters. The methods used for selecting clusters at the first stage are similar for household-, clinic-, and school-based surveys. The selection of individuals (the second stage of selection) differs between household-based surveys and clinic- and school-based surveys. In household-based surveys, households are selected and then eligible individuals within the households are assessed. In clinic- and school-based surveys, clinics are schools are selected and then individuals selected from clinic or school records using simple random sampling or systematic sampling.

Whether the survey is household-, clinic-, or school-based (or a combination of these) depends on the target groups discussed in Chapter 2 (see Table 2.4). Most of this chapter will focus on selecting communities or enumeration units at the first stage of sampling, and then households at the second stage. The basic principles of this methodology would apply equally well to clinic-based surveys (i.e., selecting clinics at the first stage of sampling, and then from clinic records, selecting individuals) and school-based surveys (i.e., selecting schools at the first stage of sampling, and then from an enrollment listing, selecting students).

3.4   Independent Survey vs. Incorporating Micronutrient Indicators into another Survey

Information on vitamin and mineral deficiencies may be collected through an independent survey or as a component of another population-based survey. Other surveys in which micronutrient information could be added include the UNICEF Multiple Indicator Cluster Survey (MICS), the Demographic and Health Surveys (DHS), and the Centers for Disease Control and Prevention (CDC) Reproductive Health Surveys. The three rounds of MICS (1995, 2000, and 2005) have included modules on coverage of micronutrient-related interventions, such as vitamin A supplement usage and iodized salt. DHS has modules that include collecting hemoglobin and micronutrient intervention coverage, such as iodized salt, and some Reproductive Health Surveys have included hemoglobin measurements. It would be important to determine whether one of these surveys is being planned and whether a micronutrient module could be added to that survey.

Incorporating a micronutrient component to another planned survey may have the following advantages:

- Reduced cost
- A sampling frame will be developed by the lead agency

- Skilled survey staff
- Logistics support

At the same time, there are a number of potential disadvantages:

- May require additional time in the field compared to an independent micronutrient survey if the planned survey is of a larger sample size and will take longer to complete data collection
- Refusal rate to the original survey protocol may be higher when biologic specimens are collected as an added component of the micronutrient survey
- Specialized training and capacity of field workers required when bio-markers are collected

To determine whether to incorporate (or "piggyback") a micronutrient component onto another survey, two important questions should be considered:

1. Will a nationally representative sample be selected?
2. Will the survey be of adequate sample size? (Sample size is discussed in the next section)

The MICS, DHS, and CDC Reproductive Health surveys generally meet the above criteria. If the sample size of the planned survey is larger than needed for the micronutrient component, a sub-sample of clusters, households, or subjects could be selected for the micronutrient component. If the 'piggy-back' approach is not an option, it may still be possible to use the sampling frame from one of the above surveys for an independent vitamin and mineral deficiency survey. The advantage to this approach is that the first-stage sampling may have been performed and the maps and information to identify households and subjects may already be developed and available. Finally, if it is not possible to incorporate a micronutrient component to another survey, then an independent micronutrient survey will need to be designed and implemented.

3.5 Sample Size Calculations

Sample size calculations can be a source of confusion because different individuals may arrive at different recommended sample sizes, primarily because sample size calculations are based on a number of decisions and estimates. There may also be slight differences between hand calculated sample size estimates and computer-based calculations due to rounding and slight variations in sample size formulae, but these differences should be minor. We present three approaches to sample size calculations: 1) Estimating a proportion for a single cross-sectional survey; 2) comparing differences between two cross-

sectional surveys; and 3) subgroup comparisons within a survey and their effect on sample size. The second situation is used when the impact of intervention between two cross-sectional surveys is desired, usually a baseline survey and a follow-up survey. For all approaches we assume 95% confidence intervals are desired and that the primary measure of interest is a proportion.

In most surveys, information on many indicators is collected, each of which might result in a different sample size estimate. It is recommended that the final sample size for a survey be based on the *most important* indicators. Computer-based programs to perform sample size calculations can be found at www.OpenEpi.com. Keep in mind that not all information needs to be collected on every survey subject or household. For example, more expensive tests might be performed on a sub-sample, such as every other survey participant so long as minimum sample size requirements are satisfied.

3.5.1   Sample size for proportion in single cross-sectional survey

To estimate a sample size for a proportion in a single cross-sectional survey, three numbers are needed:

1. Estimate of the expected proportion (*p*)
2. Desired level of absolute precision (*d*)
3. Estimated design effect (*DEFF*)

The sample size formula is:

$$n = \frac{1.96^2 \, p(1-p)(DEFF)}{d^2}$$

If the expected proportion *p* for an indicator is not known, usually the value of 0.5 (or 50%) is used because it produces the largest sample size (for given values of *d* and *DEFF*). If the proportion is expected to be between two values, select the value closest to 0.5. For example, if the proportion is thought to be between 0.15 and 0.30, use 0.30 for the sample size calculation.

The level of absolute precision *d* specifies the width of the confidence interval, e.g., $\pm$0.03 (i.e., $\pm$3%), $\pm$0.05 (i.e., $\pm$5%) or $\pm$0.10 (i.e., $\pm$10%).   For example, if the proportion estimated were 40%, would a precision of $\pm$10% (i.e., 95% confidence limits of 30% and 50%) be acceptable? If not, would a narrower confidence interval (35%, 45%), i.e., precision of $\pm$5%, be acceptable? The selection of a value for *d* (the desired absolute precision) may depend on the expected proportion and the purpose of the survey.

Common values for *d* are usually around ±5% for estimated proportions in the range of 20%-80%, and around ±3% for less common or very common events (<20% or >80%).

The sample size required for a cluster survey is almost always larger than that required for surveys using simple random sampling because of the design effect (*DEFF*). If the prevalence or coverage of a particular indicator is similar in each cluster, the *DEFF* will be around one, which means the variability is the same as would have been with simple random sampling methods. The greater the clusters differ from one another, the larger the *DEFF*. As the DEFF increases the sample size must be increased to maintain a desired level of precision. See Appendix 5 for sample size calculations for a number of different *p*, *d*, and *DEFF* estimates.

After a survey has been completed and the data analyzed, any calculated proportion is an *estimate* of the proportion in the whole population. Generally a confidence interval is calculated to present a range of values within which the true proportion is likely to be captured. For example, if the proportion is 40% and the lower and upper 95% confidence limits are 30% and 50%, respectively, the interpretation would be that the true proportion in the population most likely lies somewhere between 30% and 50%. This means that it would be very unlikely for the true population proportion to be below 30% and very unlikely for it to be greater than 50%.

Experience from surveys of anemia, vitamin A deficiency, and iodine deficiency with around 30 individuals sampled in each of 30 clusters have DEFFs in the range of 1.5 to 3. If more than 30 individuals are sampled per cluster, the DEFF is usually larger; if fewer than 30 individuals are sampled per cluster, the DEFF is usually smaller. Sample sizes for different key indicators, based on estimated prevalence levels, design effects, confidence levels, and precision are presented in Table 3.1. Please note that these are only examples and the actual sample size required for an individual country survey will vary.

As an example, the sample size calculation to assess vitamin A capsule coverage, assuming $p = 0.5$, $d = .05$, and *DEFF* = 2:

$$n = \frac{1.96^2 \times .5 \times .5(2)}{.05^2} = 768.32$$

Table 3.1 Examples of sample size calculations for key micronutrient indicators

Micronutrient/Indicators/Group	Expected Prevalence/ Coverage (*p*) (%)	Absolute Precision (*d*) (%)	Design Effect *DEFF*	Sample Size[a]
Indicators based on *individuals*				
VAD and capsule coverage				
Low Serum retinol in preschool children	10-15	± 3.0	2.0	1088
Vitamin A capsule coverage	80-90	± 3.0	2.0	1365
IDA and supplementation coverage				
Anemia	40-60	± 5.0	2.0	769
Iron deficiency anemia	15-30	± 5.0	2.0	769
Iron tablet coverage in appropriate group(s)	20-40	± 5.0	3.0	1106
IDD				
Low urinary iodine	10-30	± 5.0	2.0	646
Indicators based on *households*				
Households using vitamin A fortified product	25-75	± 5.0	2.0	769
Households using iron fortified product(s)	20-40	± 5.0	3.0	1106
Households using iodized salt	50-75	± 5.0	3.0	1152

[a]   Sample sizes are calculated for each strata based on 95% confidence intervals ($\alpha = 0.05$), expected prevalence/coverage levels closest to 50%, desired absolute precision, and estimated design effect

Sample sizes are always rounded up, so the sample size from the example would be 769. In some settings, a different precision value and/or different expected DEFF value may be appropriate. For example, if the prevalence of anemia is thought to be 60%, this would indicate that anemia is a severe problem in the population; it could be decided that a precision of ±10% would be adequate because any anemia prevalence estimate in a population ≥40% is considered to indicate a severe anemia problem, so a very precise estimate may not be necessary. On the other hand, if the proportion is very low or very high, for example, if the proportion of households using iodized salt is thought to be 92%, it some situations it may be desired to have greater precision than ±5%, perhaps ±2.5%. In general, when performing sample size calculations or using sample size tables, careful consideration should be given to the values used in the calculation.

3.5.2   Sample size calculation for comparing two surveys

In some situations two sequential cross-sectional surveys are planned to assess the estimated impact of interventions; frequently the first cross-sectional survey is to establish a pre-intervention baseline estimate, and then after a period of time (perhaps 1-5 years), a second cross-sectional survey ("follow-up" survey) is performed. The sample size estimates for this study design requires a number of assumptions

and preferences for certain values. In the calculations below it is assumed that the sample size in each of the two surveys will be the same.

Estimates and preferences are needed for:

p_1 The estimated proportion with deficiency or intervention at baseline survey

p_2 The estimated proportion with deficiency or intervention at follow-up survey

DEFF   The estimated design effect (while the formula assumes the *DEFF* will be the same for both surveys, realistically the *DEFF* may differ between surveys, therefore it is recommended to provide the larger estimated *DEFF*)

α   Level of significance ("alpha"), usually 0.05 or 5% (corresponds with 95% confidence interval)

1- β   Power, usually 0.8 (80%) or 0.9 (90%)

The formula is:

$$n = DEFF \times \frac{\left[Z_{\alpha/2} \sqrt{2\overline{pq}} - Z_{1-\beta} \sqrt{p_1 q_1 + p_2 q_2} \right]^2}{(p_1 - p_2)^2}$$

where

$$\overline{p} = \frac{p_1 + p_2}{2} \text{ and } \overline{q} = 1 - \overline{p} \text{ when sample sizes are to be equal}$$

$q_1 = 1 - p_1$

$q_2 = 1 - p_2$

$Z_{\alpha/2}$ is the Z-value for the level of significance

$Z_{1-\beta}$ is the Z-value for the Power

In general we would recommend an α of .05 and β of .20. The Z-value for these and some other common Z-values for the level of significance and Power are provided in Tables 3.2 and 3.3, respectively.

Table 3.2. Two-sided Z-values ($Z_{\alpha/2}$) for various significance levels

Significance level (α)	2-sided Z-value
0.01	2.576
0.05	**1.960**
0.10	1.645

Bold indicates usual value used

Table 3.3 One-sided Z-values ($Z_{1-\beta}$) for various Power (1- β) levels

β value	Power (1- β)	1-sided Z-value
0.01	.99	-2.326
0.05	.95	-1.645
0.10	.90	-1.282
0.20	**.80**	**-0.842**

Bold indicates usual value used

Example: A country is going to begin fortifying flour with iron. They estimate the baseline prevalence of anemia to be 50% in women of reproductive age, and expect that iron fortification of flour will lower the anemia prevalence in this group to 40%.

Example of sample size calculation:

$p_1 = 0.50$, $q_1 = 0.50$

$p_2 = 0.40$, $q_2 = 0.60$

$\alpha = 0.05$, therefore $Z_{\alpha/2} = 1.96$

$\beta = .20$, therefore $Z_{1-\beta} = -.842$

$DEFF = 2$

Need to calculate $\bar{p}$. For equal sample sizes:

$$\bar{p} = \frac{.50 + .40}{2} = .45, \ \bar{q} = 1 - .45 = .55$$

$$n = 2 \times \frac{\left[1.96\sqrt{2(.45)(.55)} - (-.842)\sqrt{(.50)(.50) + (.40)(.60)}\right]^2}{(.50 - .40)^2} = 2 \times \frac{3.876}{.01} \approx 776$$

In this example, the sample size would be 776 individuals in each cross-sectional survey, i.e., 776 for the baseline survey and 776 in the follow-up survey.

3.5.3   Subgroup Comparisons and their affect on sample size

The sample sizes in Section 3.5.1 assume that a single overall (nutrient) deficiency prevalence or program coverage estimate is desired from a survey, such as the prevalence of VAD in preschool children or prevalence of IDA in women of reproductive age, or percent of households using iodized salt. If an objective of the survey is to compare subgroups within the survey, such as comparing males to females, then the sample size would likely be larger depending upon the level of precision desired for the comparison(s). Another example might be to compare the prevalence of deficiency in households *not*

using a fortified food compared to households using a fortified food. If these types of comparison are important, then the sample size will need to be increased to assure adequate precision for each subgroup. If it is expected that the two subgroups are equally distributed in the population (such as females and males, where in most populations around 50% of the population is female and 50% male), then the sample size presented in the previous section (3.5.2) could be used, only substituting the estimated prevalence for each of the two subgroups. If the two subgroups differ in size, another sample size formula should be used which is described next.

For example, suppose the prevalence of anemia in households using iron-fortified flour is to be compared to the prevalence of anemia not using iron-fortified flour, and it is estimated that 80% of the households use iron fortified flour. The sample size formula is:

$$n_1 = DEFF \times \frac{\left[Z_{\alpha/2}\sqrt{(r+1)\overline{p}\overline{q}} - Z_{1-\beta}\sqrt{rp_1q_1 + p_2q_2}\right]^2}{r(p_1 - p_2)^2}$$

$$n_2 = r\,n_1$$

where

$$\overline{p} = \frac{p_1 + rp_2}{r+1}$$ and $\overline{q} = 1 - \overline{p}$ when sample sizes are to be unequal

Different from the formula in section 3.5.2 is an additional term r, which for our example would be the proportion of households ***not*** using iron-fortified flour divided by the proportion of households using iron-fortified flour. In the above example, $r = .2 / .8 = .25$. Two sample sizes are calculated:

- n_1 = the number of households using the fortified product
- n_2 = the number of households ***not*** using the fortified product

For example, assume the following:

$p_1 = 0.40$, the prevalence of anemia in households using iron-fortified flour

$p_2 = 0.50$, the prevalence of anemia in households ***not*** using iron-fortified flour

$r = 0.2 / 0.8 = 0.25$

$\alpha = 0.05$, therefore $Z_{\alpha/2} = 1.96$

$\beta = 0.20$, therefore $Z_{1-\beta} = -0.842$

$DEFF = 2$

$$\bar{p} = \frac{.4 + (.25 \times .5)}{.25 + 1} = .42 \text{ and } \bar{q} = 1 - .42 = .58$$

$$n_1 = 2 \times \frac{\left[1.96\sqrt{(.25 + 1)(.42)(.58)} - (-.842)\sqrt{.25(.40)(.60) + (.5)(.5)}\right]^2}{.25(.40 - .50)^2} = 2 \times \frac{(1.0816 + .4688)^2}{.0025} = 1,923$$

$$n_2 = .25(1923) = 481$$

Therefore, the survey would need to include 2,404 individuals, of which 1,923 would be expected to be from households that use iron-fortified flour and 481 would be expected *not* to use iron-fortified flour.

3.5.4   Accounting for Response Rates

Another important issue to consider when calculating a sample size for a survey is to take into account the potential response or compliance of the population to be surveyed. Nonresponse can occur at many levels, such as:

- None of the household members may be available during the survey (the household is away on a temporary basis)
- The entire household may refuse to participate
- Some individuals within a household may refuse to participate or may not be available during the survey
- Some individuals may partially participate, such as agreeing to answer questions but refusing blood collection
- The volume of blood collected may be insufficient for laboratory analysis

All of these potential reasons for nonparticipation or nonresponse should be taken into account and the final sample size is determined by dividing the calculated sample size, as shown in sections 3.5.2 and 3.5.3, by the expected response. For example, if the calculated sample size is 768 and a 90% (i.e., 0.9) response is expected, then the final sample size would be 768 / 0.9 = 853.3 or 854 (always round up). Thus, if 854 individuals are invited to participate in the survey and 90% agree to do so, then it would be expected that the sample size of 768 individuals would be met.

3.5.5   Number of Households

We describe two methods in household-based cluster surveys for determining the number of households to select in each cluster. One method is to select a pre-determined number of households in each cluster (the "fixed number of households" method). Another method, called the "quota" method, is described in Chapter 4 and has survey teams visit households until the desired number of eligible individuals has been identified.

Some indicators, such as the prevalence of anemia, relate to individuals, while other indicators relate to households, such as the proportion of households using iodized salt. If a **fixed** number of households are to be surveyed in each cluster, the following information, usually available from the ministry responsible for the census, is needed to determine the number of households:

- Largest sample size requirement based on the primary indicators to be measured

- Average number of persons per household

- Proportion of target population out of total population

The number of households to select in each cluster would be determined using the following formula:

$$nHH = \frac{n}{\overline{HH} * pp}$$

where

nHH = total number of households to sample in a survey

n = total sample size for number of individuals

$\overline{HH}$ = average household size

pp = proportion of the population in target group

As an example where the indicator of interest is the prevalence of anemia among women of reproductive age:

- the calculated sample size is 768 women
- the average number of individuals per household 3.9
- women of reproductive age represent 0.31 (31%) of the population

Thus, nHH = 768 / (3.9 x 0.31) = 636 households (rounded up to a whole number) would need to be assessed in the survey area. Note that in this example $\overline{HH}$ x pp is the average number of women of

reproductive age that would be found in each household; 3.9 x 0.31 = 1.209, i.e., on average, there will be 1.209 women of reproductive age in each household.

3.6 Number of clusters and samples per cluster

Two issues to consider when applying sample size calculations to cluster surveys are how many clusters are needed, and once this is determined, how many samples (individuals or households) are to be surveyed per cluster.

3.6.1 Number of Households/Individuals per Cluster and the Number of Clusters

The number of clusters to assess depends on many factors, such as the size of the geographic area (which affects costs in terms of teams traveling from one cluster to another), the amount of time a survey team spends in a cluster, the primary purpose of the survey, whether there is a single national cluster survey or a stratified cluster survey, and many other factors. Here are some general guidelines for micronutrient surveys:

- Within each cluster, generally there should be between 10 and 40 individuals in the most important target groups. Having fewer than 10 individuals may lead to unstable variance estimates (at least in surveys with 30 clusters) and going beyond 40 results in little improvement in precision (described in the next section). If the collection and/or analysis of information are of significant cost, such as collecting blood specimens for laboratory analysis, then the fewest samples per cluster with adequate precision should be collected. If the cost of collecting information is low, such as asking about vitamin A supplementation, then including more than 40 may be reasonable, however it will have little effect on improving precision. The underlying issue is to balance the costs of data and specimen collection/processing with programmatic needs for a specified precision around the estimates. While it would seem that collecting more samples per cluster would increase precision in cluster surveys, the improvement in precision is minimal beyond 40 samples per cluster. The reason for this is that as more samples are collected per cluster, the DEFF also increases.

- There should be at least 25 clusters in each stratum and going beyond 40 clusters does not improve precision appreciably. In larger countries the cost of teams moving from one cluster

to another can be substantial, and therefore to keep survey costs down, usually the motivation is to have fewer clusters. In very small countries where travel between clusters is not a significant constraint, having a larger number of clusters would be reasonable and even improve precision. For example, for a total sample size of 900, a survey of 60 clusters with 15 individuals per cluster would be, on average, more precise than a survey of 30 clusters with 30 individuals. The reason for the improved precision is that the smaller the number of observations per cluster, the smaller, on average, the design effect.

- Another approach is to determine the number of clusters based on the number of households that can be surveyed in one or two days by a survey team, as long as there are at least 25-30 clusters in each stratum.

Collecting data from around 30 clusters with around 15-30 observations per cluster provides reasonably precise estimates (i.e., 95% confidence limits of no greater than $\pm$5% assuming a design effect of around 2.0) of nutritional status indicators in the target population.[5] Thirty cluster surveys have been used extensively for many health outcomes, such as immunizations, diarrheal disease surveys, and anthropometry surveys. For a fixed number of samples/individuals selected per cluster (e.g., 10 individuals per cluster or 30 individuals per cluster), collecting information on more than 30 clusters only slightly improves the precision of the estimate, however in some settings, mentioned previously, having more than 30 clusters is reasonable.

The UNICEF Multiple Indicator Cluster Survey (MICS) and Demographic and Health Surveys (DHS) select more than 30 clusters, sometimes up to 300 or more, and also have much larger sample sizes than described in this manual for micronutrient surveys. The primary reasons include:

- Stratification – frequently one goal of MICS and DHS surveys is to present prevalence or coverage estimates by strata, such as by province, and different demographic groups (e.g., age, sex, and socioeconomic status). Thus the sample size increases by the number of strata and for subgroup analyses.

- Size of target group – some of the target groups in MICS and DHS represent small proportions of the entire population of a country and therefore a large number of households need to be visited to recruit the desired number of participants. For example, a relatively large number of households would need to be visited to identify sufficient numbers of:
  - women who have given birth in the previous year
  - one-year old children (12 months up to 24 months of age)
  - pregnant women
  - children 0 to 6 months of age to assess breastfeeding status

- Design effects – the design effects for some indicators can be much larger than two, such as factors relating to access to potable water and adequate sanitation.

Therefore, for surveys such as MICS and DHS, having larger sample sizes and a larger number of clusters are reasonable given the above issues. Our recommendations for the type of surveys described in this manual are as follows:

- For a non-stratified national survey, fewer than 30 clusters would not be sufficient.
- For stratified surveys, at least 25 clusters should be selected in each stratum, although if less precision is required for stratum-specific estimates, the number of clusters per stratum could be reduced.

3.7 How to select clusters

In household-based surveys, communities, wards, villages, census tracts, or other defined enumeration units (EU) are designated as the primary sampling units (PSU). In determining how to select clusters, one issue is whether there are reasonably accurate estimates of the population size for the PSUs. In household-based surveys, this would be the population size or the number of households within each enumeration unit (EU); in clinic-based surveys, this would be the number of clinic enrollees; in school-based surveys, this would be the number of students enrolled in each school. If relatively accurate data on population size are available, then the preferred method for selecting clusters is the probability proportionate to size (PPS) method because this is under many settings a self-weighted design and is described in more detail in the next section. If accurate population data are not available, then either a random or systematic selection of clusters could be used. Each of these methods is described in the sections that follow.

3.7.1 PPS selection of clusters

As mentioned, clusters should ideally be selected using a technique called "probability proportionate to size" or PPS sampling. Using the PPS method, the likelihood of a PSU being selected is proportional to its population size, i.e., larger PSUs are more likely to be selected than smaller ones. The first step is to obtain the "best available" census data for all the PSUs in the geographic area to be surveyed (e.g., a country). This information is usually available from the government agency that performs the census for the country, such as a national bureau of statistics.

Countries with very organized census information will frequently have PSUs or enumeration units that are relatively small geographic areas with a population size between 100-1,000 or 20-200 households. It may be necessary to designate a minimum PSU population size to assure that enough potential respondents are available to meet the sample size per cluster; consequently, there may be situations where two or more contiguous enumeration units will need to be combined to form a single PSU.

If the enumeration unit information is either not readily accessible or is very inaccurate, the most recent estimates of population size should be obtained by village, towns, and cities that would serve as the PSUs. It is essential to include all areas, including those which may be remote and/or rural.

With the PSU information, make a list with four columns (see Table 3.4). The first column lists the name of each PSU; the second column contains the population of each PSU; the third column contains the cumulative population that is obtained by adding the population of each PSU to the cumulative population of PSUs preceding it on the list. As a general rule, it is best for the list to be in geographic order by districts or provinces. A sampling interval (k) is obtained by dividing the total population size by the number of clusters to be surveyed. A random number between 1 and the sampling interval (k) is chosen (see Appendix 6 for a table of random numbers) as the starting point and the sampling interval is added cumulatively until thirty clusters are chosen; the selected clusters are shown in the 4th column of Table 3.4.

3.7.1.i.   Example of Selecting PSUs for a Cluster Survey

In the fictitious area of El Saba, there are fifty PSUs (Table 3.4). In practice there are usually many more than fifty PSUs in a survey area. With a large number of PSUs, the selection process is usually performed using a computer. For SAS users, there is PROC SURVEYSELECT which has an option to select data using PPS. With SPSS, the optional Complex Samples module has a "Select Sample…" option. Use of spreadsheets is another method for performing the selection.

Table 3.4. Selecting communities for a cluster survey in El Saba using the PPS method

PSU	Pop.	Cum.	Cluster	PSU	Pop.	Cum.	Cluster
Utural	600	600		BanVinai	400	10,880	13
Mina	700	1,300	1	Puratna	220	11,100	
Bolama	350	1,650	2	Kegalni	140	11,240	
Taluma	680	2,380	3	Hamali-Ura	80	11,320	
War-Yali	430	2,810		Kameni	410	11,730	14
Galey	220	3,030		Kiroya	280	12,010	
Tarum	40	3,070		Yanwela	330	12,340	
Hamtato	150	3,220	4	Bagvi	440	12,780	15
Nayjaff	90	3,320		Atota	320	13,100	
Nuviya	300	3,610		Kogouva	120	13,220	16
Cattical	430	4,040	5	Ahekpa	60	13,280	
Paralai	150	4,190		Yondot	320	13,600	
Egala-Kuru	380	4,570		Nozop	1,780	15,380	17,18
Uwanarpol	310	4,880	6	Mapazko	390	15,770	19
Hilandia	2,000	6,880	7,8	Lotohah	1,500	17,270	20
Assosa	750	7,630	9	Voattigan	960	18,230	21,22
Dimma	250	7,880		Plitok	420	18,650	
Aisha	420	8,300	10	Dopoltan	270	18,900	
Nam Yao	180	8,480		Cococopa	3,500	22,400	23,24,25,26,27
Mai Jarim	300	8,780		Famegzi	400	22,820	
Pua	100	8,880		Jigpelay	210	22,840	
Gambela	710	9,590	11	Mewoah	50	22,890	
Fugnido	190	9,880	12	Odigla	350	23,240	28
Degeh Bur	150	10,030		Sanbati	1,440	24,680	29
Mezan	450	10,480		Andidwa	260	24,940	30

Follow the four steps below to select clusters to be included in the survey:

Step 1: Calculate the sampling interval by dividing the total population by the number of clusters to be surveyed. In this example, 24,940 / 30 = 831.

Step 2: Choose a random starting point between 1 and the sampling interval (k, in this example, 831) by using the random number table in Appendix 6. For this example, the number 710 is randomly selected.

Step 3: The first cluster will be where the 710th individual is found based on the cumulative population column, in this example, Mina since it includes the population from 601 to 1,300.

Step 4: Continue to assign clusters by adding 831 cumulatively. For example, the second cluster will be in the PSU where the value 1,541 is located (710 + 831 = 1541), which is Bolama. The third cluster is where the value 2,372 is located (1541 + 831 = 2372), and so on. In PSUs with large populations, more than one cluster could be selected. Note that if two clusters were selected in one PSU, when the survey is performed, the survey team would divide the area into two sections of approximately equal population size and treat each area as independent clusters. Similarly, if three or more clusters were in a PSU, the PSU would be divided into three or more sections of approximately equal population size, as is the case with Cococopa in Table 3.4 (described in more detail later).

3.7.2   Random and systematic selection of clusters

When a list of PSUs is available but the population size for each PSU is not known or very inaccurate, simple random sampling or systematic selection can be used. Systematic sampling tends to be easier to implement by hand and is described next, although simple random sampling (see Appendix 4) could also be performed. With the availability of computer programs that can sample records from a file, the preference would be to use simple random sampling. The steps for systematic sampling, should it be more convenient to implement, are as follows:

Step 1: Obtain the list of the PSUs and number them from 1 to N (the total number of PSUs)

Step 2: The number of PSUs to sample (*n*) should have already been determined.

Step 3: Calculate the "sampling interval" (*k*) by N/n (always round down to the nearest whole integer).

Step 4: Using the random number table (Appendix 6), select a number between 1 and *k*. Whichever number is randomly selected, go to the PSU list and include that PSU in the survey.

Step 5: Select every *k*th PSU after the first selected PSU.

   For illustrative purposes, Table 3.5 lists fifty PSUs and below demonstrates how to select 8 PSUs.

Step 1: There are fifty PSUs, therefore N=50.

Step 2: The number of PSUs to sample is eight, therefore n=8.

Step 3: The sampling interval is 50/8 = 6.25; round down to the nearest whole integer which is 6; therefore, *k*=6.

Step 4: Using a random number table, select a number from 1 to (and including) 6. In this example, let's say the number selected was 3. Therefore, the first PSU to be selected is the third PSU on the list, which in this example is Bolama.

Step 5: Select every 6th PSU thereafter. In this example, the selected PSUs would be the 3rd, 9th, 15th, 21st, 27th, 33rd, 39th, and 45th PSUs on the list.

   In some circumstances you might actually end up selecting more than the number of clusters needed. In the above example, had the random number chosen in Step 4 been 1 or 2, nine PSUs would have been selected rather than eight. To remove one cluster so that only eight are selected, again go to the random number table, and pick a number and the cluster that corresponds to the random number is removed from the survey. To properly analyze the data collected using systematic sampling, an estimate of the population size in each cluster should be collected when the survey team arrives on site. (Note that usually more clusters are selected; the 8 selected in this example was for illustrative purposes only).

Table 3.5 Selection of PSUs using the systematic selection method

PSU		Selected?	PSU		Selected?
1	Utural		26	BanVinai	
2	Mina		27	Puratna	Y
3	Bolama	Y	28	Kegalni	
4	Taluma		29	Hamali-Ura	
5	War-Yali		30	Kameni	
6	Galey		31	Kiroya	
7	Tarum		32	Yanwela	
8	Hamtato		33	Bagvi	Y
9	Nayjaff	Y	34	Atota	
10	Nuviya		35	Kogouva	
11	Cattical		36	Ahekpa	
12	Paralai		37	Yondot	
13	Egala-Kuru		38	Nozop	
14	Uwanarpol		39	Mapazko	Y
15	Hilandia	Y	40	Lotohah	
16	Assosa		41	Voattigan	
17	Dimma		42	Plitok	
18	Aisha		43	Dopoltan	
19	Nam Yao		44	Cococopa	
20	Mai Jarim		45	Famegzi	Y
21	Pua	Y	46	Jigpelay	
22	Gambela		47	Mewoah	
23	Fugnido		48	Odigla	
24	Degeh Bur		49	Sanbati	
25	Mezan		50	Andidwa	

3.8 Summary

This chapter described issues related to survey design and sampling strategies. The relative merits of conducting an independent micronutrient survey or incorporating a micronutrient component into another planned survey were presented. In many countries a non-stratified national survey is adequate to determine an overall estimate of nutrient status (i.e., nutrient deficiency). A 30 cluster survey with 10 to 30 individuals per population group of interest or households per cluster will usually be adequate in most cases. In some settings there may need to be a stratified survey if stratum-specific estimates are needed, and in some settings more than 30 clusters may be selected. When accurate population sizes are known, the probability proportionate to size (PPS) method is recommended for selecting clusters.

Chapter 4
Household and Subject Selection

In most cross-sectional nutrition surveys, subjects are identified from selected households within each cluster and then eligible individuals assessed within the sampled households. Usually a local definition of "household" and "dwelling" are used because these may vary from country to country. In this document the following definitions are used:

- A *household* is a group of persons who eat from the same kitchen

- A *dwelling* is a building or residential unit and may include one or more households.

Definitions of household and dwelling must be made clear and specific to assure that survey teams operate consistently in the field when identifying and selecting households.

In some countries, a list or map of dwellings or households within a PSU may be available through a local government administrative office or the census bureau. This allows for the selection of households from the list or map.

Two methods are described for selecting households in a cluster, "fixed" versus "quota." For the fixed method, the number of households to select in each cluster is determined in advance, most commonly the same number of households being assessed in every cluster, e.g., 10 households, or 15 households. The team knows, prior to arriving at the cluster, the number of households to approach and invite to participate in the survey. The "quota" method of household selection is where the survey team visits households until they identify a predetermined number of households or individuals eligible and/or willing to participate in the survey. Some surveys use the quota method based on the number of eligible *individuals* in each cluster, such as EPI surveys where the survey team visits households until they identify 7 children from 12 months to 24 months of age; the team does not know in advance how many households will need to be visited in order to identify and assess 7 eligible and participating children. Most micronutrient surveys use the "fixed" method because they tend to have several targets of interest: the household; pre-school children; women of reproductive age, etc., compared to the EPI survey in which the primary interest is in preschool children. For nutrition surveys the fixed number of households approach is recommended.

Another issue is how to select households within a cluster. One approach is to carefully map all households within the cluster and then either randomly or systematically select households to survey. Another approach is to randomly select one household within the cluster and then select subsequent households using the "next nearest household" approach as frequently used in EPI surveys, or select households in a specified direction. With the random or systematic selection households, having a relatively accurate map or listing of households is important, whereas for the "next nearest household" or selection of households in a specified direction, accurate mapping is less important. In both situations, if the cluster is very large in terms of the number of households within the cluster, it may be necessary to first segment the cluster, which is described in the next section.

4.1   Segmenting clusters

Clusters may vary widely in the number of households and/or population size. Large clusters may need to be divided into smaller geographic areas within which households can more easily be identified and selected. The terms "segments" (in some documents referred to as "quadrants") and "subsegments" will be used to describe this process. If a cluster is very large and it is not possible to identify households, the following steps are recommended:

1. Divide the cluster into approximately equal size segments (in terms of the number of households or population size)

2. Randomly select one segment

3. If the segment is still too large, then *sub*segment the area and randomly select one *sub*segment.

4. For the random or systematic selection of households, there will be a need to map or listing the households within the selected segment/subsegment

5. Select households

If up-to-date maps of large clusters are available, the survey segments should be identified prior to the survey team's arrival to the cluster. If maps are not available, a survey "census" team could visit each cluster and select the segments and households prior to the arrival of the survey team; alternatively, the survey team itself may do this task upon arriving at the cluster, in which case the added time for this activity should be included in the survey schedule.

Figure 4.1 illustrates examples of the use of random or systematic selection of a fixed number of households with different cluster characteristics and steps to take to select households in a cluster. In this example it is assumed that the average household size is 7.4 individuals, the number of households to be assessed was 30, and the goal was to identify a cluster/segment between 30-60 households, i.e., a segment from 1 to 2 times the number of households to be sampled. In some settings, the survey management team may choose to have segments that are 2-4 times larger than the number to be assessed. There are a number of advantages and disadvantages to be weighed in determining the segment size. For example, if households are to be selected randomly or systematically from the area to be surveyed, if the area is large, this could increase the amount of time it takes teams to get from one household to the next and may make supervision more difficult when there are two or more groups of surveyors in a cluster.

Large clusters, such as cities, may already have political subdivisions with an estimated number of households or population size (for an example, see Figure 4.2). If political subdivisions already exist, one can use these subdivisions to define segments.

Figure 4.1. Example of cluster size (in terms of households or population size) and approaches to determining area (i.e., segment) to survey.*

Large cluster >450 households *or* >3500 population	**Intermediate size cluster** 60-450 households *or* 450-3500 population	**Small cluster** <60 households *or* <450 population
↓	↓	↓
1. Divide cluster into segments consisting of approximately 60-450 households (or 450-3500 population) per segment 2. Randomly select one segment	↓	↓
↓	↓	↓
1. Divide selected segment into subsegments consisting of approximately 45 households (range of 30-60 households) or a population of 300 (range of 225-450 population) per subsegment 2. Randomly select one subsegment	1. Divide cluster into segments consisting of approximately 45 households (range of 30-60 households) or a population of 300 (range of 225-450 population) per segment 2. Randomly select one segment	↓
↓	↓	↓
Select 30 households within selected subsegment	Select 30 households within selected segment	Select 30 households within cluster

*As an example, assume 30 households are to be selected in each cluster and there are approximately 7.4 individuals per household

Figure 4.2. Mazari-Sharif by District and Gozar, Afghanistan
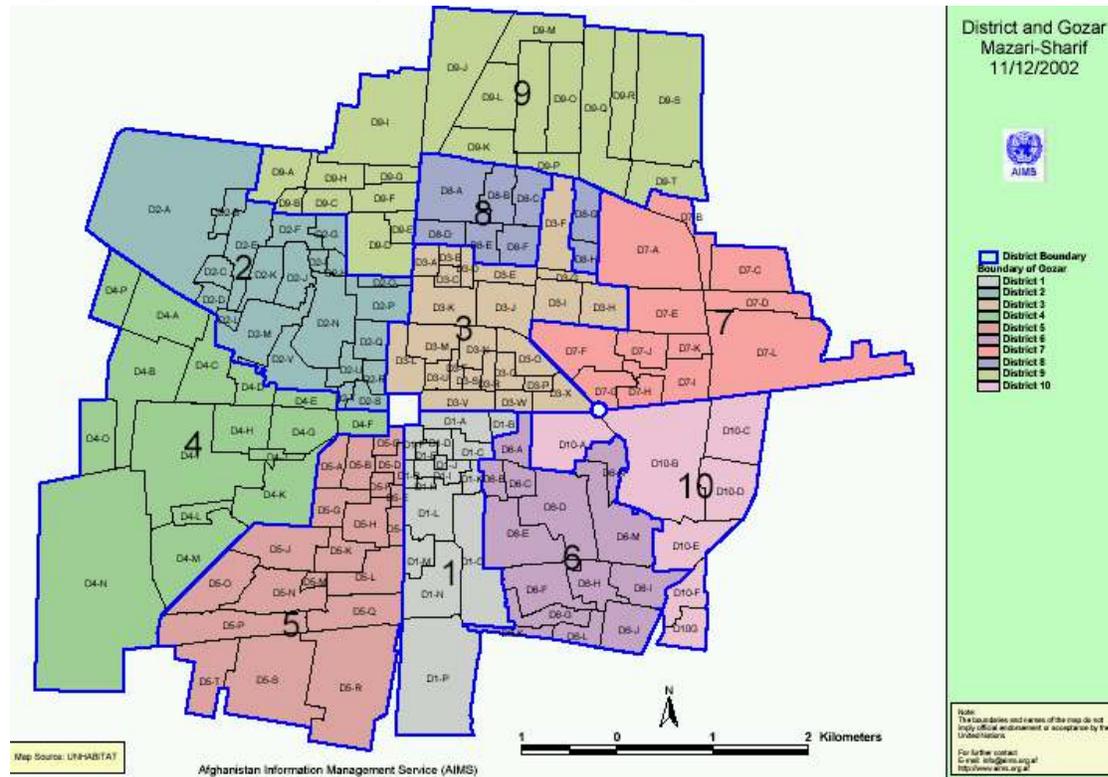
If there are no defined subdivisions for a large cluster, the following steps could be used to subdivide the area using the example of 30 households per cluster:

- From a map, divide the cluster into segments using easily recognizable boundaries, such as rivers and roads.

- Sequentially number the segments and then randomly select one segment.

- Divide the selected segment into subsegments with approximately 30-60 households each.

- Sequentially number the subsegments and then randomly select one subsegment.

- Select 30 households within the selected subsegment.

Assuming, for example, 30 households are to be selected in a cluster and the number of households in the cluster is known (and is between 60 and 450), to determine the number of segments, divide the total number of households in the cluster by 45:

Example 1: a cluster has 115 households:

$$115 \div 45 \approx 3$$

Thus, the cluster should be divided into 3 approximately equal size segments.

Example 2: a cluster has 320 households:

320 ÷ 45 ≈ 7

Thus, the cluster should be divided into 7 approximately equal size segments.

If the number of households in the cluster is not known but a population size estimate is available, then this information can be used to determine the number of segments. The standard segment size is determined by multiplying a "standard number" (i.e., 45) of households per segment by the average number of subjects per household. Thus, if we assume an average of 7.4 persons per household:

45 x 7.4 = 333 (this can be rounded down to 330 individuals).

Example 1: a cluster has a population size of approximately 850:

850 ÷ 330 ≈ 3

Thus, the cluster should be divided into 3 approximately equal size segments.

Example 2: a cluster has a population size of approximately 3,850:

3850 ÷ 330 ≈ 12

Thus, the cluster should be divided into 12 approximately equal size segments.

In the above example, if the total estimated population of the cluster is less than 450, segmentation is not necessary. It should be possible to count the total number of households in a cluster of this size, and then select the needed number of households to be surveyed (in the above example, 30).

4.1.1 How to Map a Cluster/Segment When Accurate Maps Are Not Available

In the guidance below, it is assumed that 30 households are to be surveyed in each cluster using the random or systematic selection of a fixed number of households method.

Step 1: **Prepare a sketch map; identify and draw the outer boundaries of the cluster.** With the help of a local guide, draw a map marking the boundaries of the cluster, identifying the major roads, lanes, streets and showing physical boundaries such as streams, and rivers.

Step 2: **Draw internal markers**, which will help identify locations and aid in establishing a path of travel. These would include internal streets, paths, streams, and so forth.

Step 3: **Mark the location of each dwelling unit on the map**. For help in later locating the households, it is also useful to mark other prominent buildings—schools, churches, mosques, etc.

Step 4: **Count the number of dwellings in the cluster and divide by 45**. This will give you the

For purposes of mapping and/or segmenting a cluster, absolute precision in the count of households is not necessary. A good approximate count of dwellings is sufficient.

approximate number of segments in which the cluster should be divided. Note that this exercise should be a "quick count" operation to locate dwellings. It does not require knocking on doors to inquire about households or the names of occupants. An exception is multi-dwelling buildings that appear to include several households—for example, in the case of large compounds or apartment buildings, where you should ask about the number of households and record it on your map.

Step 5: **Based on the sketch map, divide the cluster into the number of segments (calculated in Step 4) with *approximately* the same number of dwellings.** This means that the size of the segments in terms of geographic area may vary considerably—densely populated areas will have geographically smaller segments and less populated segments will be larger.

Segments should be designated with easily identifiable boundaries and landmarks to facilitate field work. An example of a sketch map is shown in Figure 4.3; each segment includes approximately 45 dwellings. It is acceptable to have a slightly unequal number of households per segment in order to create segments with clearly identifiable boundaries.

Figure 4.3
Sample Cluster and segments
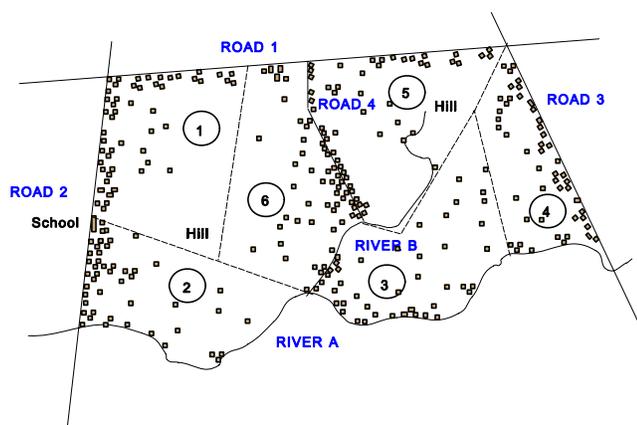
Step 6: **Select one segment.** Using a random number table (see Appendix 6), choose a random number between 1 and the number of segments in the cluster. Note that the random method of "picking numbers from a hat" could also be used, where the segment numbers are written on separate pieces of paper and folded in half to hide the number, placed in a hat or bowl, and one selected. If possible, the person who selects the segment should not be the same one who identified the segments, in order to prevent any inadvertent bias.

Segmenting urban areas may be easier than segmenting rural areas. Cities and towns are usually organized into blocks or other similar units. When using census enumeration areas in cities and larger towns, maps are usually available showing streets and blocks. If unavailable, such maps can be easily drawn. A quick drive through the area will let you know whether there are an approximately equal number of dwellings per block. If so, the cluster could be segmented by blocks, or parts of blocks.

> **Example**: Let us suppose that an urban cluster includes 18 very similar blocks and they are to be divided into seven segments. Divide 18 by 7 to obtain 2.6 blocks per segment. Divide the cluster into seven segments with two and a half blocks each (the last segment will include three blocks).

If the number of dwellings per block varies considerably, approximate the total number of dwellings in the cluster and dividing them into segments with a similar number of dwellings. When sketch-mapping rural areas you usually do not have to worry about separating dwellings from households, however in urban areas you may need to determine the number of households in multi-story buildings (e.g. apartment buildings).

4.1.2 More Detailed Map of Area Selected and Selecting Households – Random or Systematic Selection of a Fixed Number of Households Method

Once the precise area where the survey is to be performed is determined, the sketch-map of the area may need to be double-checked and improved upon. This may mean visiting the segment and double-checking the accuracy of the location of the households and placing additional landmarks on the map (See Figure 4.4). If possible, an official of the area could assist with determining which dwellings are occupied and which dwellings have multiple households. In areas where groups of households live in compounds or large buildings, you may need to visit the site and determine the number of households. If it is found that there are many more than 60 households in the segment/cluster, then it may be necessary

to divide the area into approximately equal size subsegments based on number of households, and randomly select one segment to survey.

Figure 4.4. Close up of Segment 4 as shown in Figure 4.3.
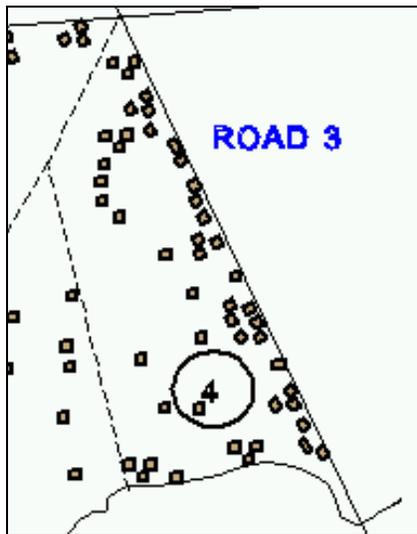
4.1.2.i Questions and Answers concerning Segmentation with Random or Systematic Selection of a Fixed Number of Households

- What is the ideal cluster/segment size for a survey?
    - Different investigators may have different preferences. One possible rule is that when randomly or systematically selected households, usually there should be 1 to 3 times the number of households to be assessed in the cluster/segment. A value of 1 means every household in the segment is assessed, and a value of 3 means every third household is assessed. For selecting the next nearest household or households in a specified direction, this is less of an important issue.
- What if there is fewer than the number of households to be assessed within a selected village?
    - One approach is to survey all the households in the cluster and select remaining households from the nearest village. This is considered a reasonable approach in that households in a neighboring village are likely to be similar to those in the selected village. For example, if 30 households are to be assessed in each cluster and the team visits a cluster and finds it only contains 20 households, they would need to go to the next village and select 10 households most likely using a segmentation approach.

- If the village has just slightly below the number of households to be assessed in each cluster (say 1 or 2 households less than required), usually the team would just assess the households in the cluster and not attempt to go to the next nearest village. The survey protocol should have specific instructions on how to deal with various scenarios.

4.2 Selecting Households using Random or Systematic Selection of a Fixed Number of Households

On the map, sequentially number the households from 1 to the number of households in the segment. If a dwelling has multiple households, assign each household its own number. Figure 4.4 shows segment 4 from Figure 4.3; the households in this segment would need to be numbered from 1 to 49.

4.2.1 Random or systematic selection of a fixed number of households

Simple random or systematic sampling of a fixed number of households, from a statistical viewpoint, is the preferred method for selecting households in a selected cluster or segment. Both methods generally require an accurate map of the cluster or segment with households sequentially numbered as described previously. Using the example of assessing 30 households in each clusters, if there are >30 households, then randomly select households to be surveyed using a random number table or by picking numbers from a hat. Examples of random and systematic sampling are provided next.

4.2.1.i Example of random sampling approach:
   a. Assume a segment includes 60 households and 30 are to be selected.
   b. Number the households from 1 to 60.
   c. Use a random number table (Appendix 6) to select 30 unique numbers between 1 and 60 to identify the 30 households based on the random numbers selected.

4.2.1.ii   Example of systematic sampling approach:
   If systematic selection of a fixed number of households is to be used, if the teams are to assess 30 households and if there are exactly 60 households in the cluster, then they would randomly select the

number 1 or 2. If the number 1 is selected, all odd numbered households are assessed. If the number 2 is selected, all even numbered households are assessed.

  a. Calculate a sampling interval (number of households in segment ÷ 30 households to be surveyed): $60 \div 30 = 2$ (every second household would be surveyed)
  b. Number the households from 1 to 60.
  c. Select a random number between 1 and sampling interval (in this example, 2).
  d. To identify the first household, select household number 1 or 2 on the map depending on the random number selected.
  e. Select every 2nd (sampling interval) household; in this example, this would either be the even numbered or odd numbered households.

It is unlikely that there will be exactly 1, 2, or 3 times the number of households in the cluster/segment. For example, say 30 households are to be assessed and there are 36 households in the cluster/segment. First, the sampling fraction is the number of HH is the cluster divided by the number of HH to be sampled, in this example, $36/30 = 1.2$. This means every 1.2 households are to be selected. To do the selection, first pick a random starting value, either 1 or 2, then assess every 1.2 households by rounding. For example, say "1" is the randomly selected, so household 1 is assessed; add 1.2 which is 2.2 $(1 + 1.2 = 2.2)$, round down to 2 and assess household number 2; add 1.2 $(2.2 + 1.2 = 3.4)$, round down and assess household number 3; add 1.2 $(3.4 + 1.2 = 4.6)$ which would be rounded up to 5, so assess household 5, and so on. For this cluster, the selected households would be:

1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 35, 36

Alternatively, another option is to systematically select, in this example, the six households to *not* assess. The sampling interval would be $36/6 = 6$, randomly select a number between 1 and 6, remove that one from the selection, and then remove every 6th household. For example, say the random number was 4, so household 4 would *not* be selected; $4 + 6 = 10$, so exclude household number 10; $10 + 6 = 16$, exclude household number 16, and so on.

4.2.1.iii General Issues on Random or Systematic Selection of a Fixed Number of Households

The survey team should survey only selected households. If during the survey one of the dwellings to be surveyed is found to have more than one household, determine how many households occupy the dwelling and randomly select one to survey. If acceptable to the head of household, the team supervisor can mark entrances to identify dwellings to be surveyed as well as those already surveyed.

4.3   Random selection of first household

Another approach is to randomly select the first household and then select subsequent households in a specified manner. This approach can be used with the fixed number of households or quota sampling approaches. The selection of the first household can be done using different methods depending upon the size of the segment and whether a listing or map of households is available. These steps are described in more detail below.

4.3.1 Selecting the First Household

If the survey is to be performed in a large area, such as a city, it may be necessary to first divide the area into segments or subsegments described previously. For the cluster/segment to be surveyed, a map must be available and the steps for selecting households are:

Step 1:   Number all of the households.

Step 2:   Randomly select a number from 1 to the highest numbered household. The number can be selected using a random number table or other predetermined method.

Step 3:   Go to the selected household.

4.3.2 Selecting Subsequent Households

We recommend that, based on the map used to select the first household, subsequent households be selected based on the map using prespecified rules. For example, on the map, draw a line the houses to the left of first household (facing the household to the street); continue to select households to the left. If an intersection is reached, turn left, and continue the household selection process.

   We do not recommend using the "next nearest household" approach as presented for EPI surveys because this may bias the results.

4.4   Some general notes on the household selection process

Some important issue on assessing clusters and households include:

- A survey team must survey only the clusters as determined by the survey coordinator. Survey teams should never substitute another site as a cluster unless instructed to do so by the national survey coordinator.
- All those involved in planning and implementing the survey should understand that the primary purpose of the survey is NOT to estimate the prevalence of micronutrient deficiencies in selected clusters, but to derive a national estimate, or in the case of a stratified survey, stratum-specific estimates. In some clusters, those surveyed may primarily consist of lower income households, while in others they may consist of higher income households. When data from all clusters are combined, the results will provide a reasonably valid national estimate.
- At the cluster level, e.g., a village, it is important that the village leaders understand that a specific method will be applied in their village to select households, and the same method will be used in all other villages selected for the survey. The selection of an area or households to be surveyed should never be influenced by local officials or based on convenience to field workers. However, local officials can be helpful in providing legitimacy to the survey team and improve the likelihood that people would participate in the survey.
- When discussing the survey with local officials, try to confirm the population size of the cluster, the number of households, the availability of maps, and other information that might be useful to most readily identify and randomly select households. Local officials can also be helpful in providing information on the boundaries of the cluster or segments so that sketch maps can be easily developed if needed.
- Team members should understand that the purpose of a national micronutrient survey is to assess a cross-section of the population to develop a valid estimate of the prevalence of nutrient deficiencies and coverage of interventions across the country. Confusion can arise when survey team members or local officials incorrectly believe the goal is to seek and identify individuals with deficiencies.

It is expected that in some clusters fewer than the predetermined number of households will actually be assessed. However, all selected households must be accounted for, and for those not participating, the reason for nonparticipation recorded. Such circumstances are to be accounted for by increasing the calculated survey sample size by an expected rate of non-complying households or individuals (as

described in Section 3.5.4). Under no circumstances would it be appropriate for survey teams to substitute households in the field. In addition:

- The survey team, not local officials, must select households to be surveyed; and

- Every attempt should be made to locate eligible individuals in selected households.

When sampling using the fixed number of households approach, the team visits the predetermined number of households in each segment. The team will attempt to gain permission to survey every selected household and eligible individuals in these households. It is expected that in some households:

- There may be no one at home while the survey team is in the cluster, even after revisiting the dwelling

- There may be no eligible individuals within the household

- Not all individuals eligible in a household will be available for the survey, even after revisiting

- Some households may refuse to participate

- In some households the head of household may provide permission for the survey team to survey household members; however, some individual members may refuse to participate

Performing the survey during hours when people are most likely to be at home or, by working with local leaders, request that people remain near their homes until the survey is completed can enhance participation of survey subjects. For households where either no one is home or some eligible individuals are not available when the survey team first visits the dwelling, a standard approach to revisiting such households should be applied by all survey teams.

4.5 Selection of eligible individuals within households

As a general rule, we recommend that everyone within a household meeting the eligibility criteria should be surveyed. For example, if one eligibility criterion is women 15-49 years of age, and there are three women meeting this criterion in the household, we would recommend that all three be requested to participate. An alternative approach would be to randomly select one of the three women, however this approach would require a sampling weight in the analysis of the data.

Chapter 5
Survey Planning, Organization, Training, and Field Work

Important components necessary to conduct a successful survey are supervision, planning, organization, and coordination, all of which require good communications. Supervision is important to assure quality data collection and adherence to the survey protocol. Coordination is important to ensure that all teams follow similar procedures. Other essential requirements are having detailed protocols for the field activities and sufficient supplies and equipment.

5.1   Supervision

One individual should be assigned as the survey manager to oversee all aspects of survey planning and implementation. Additionally, each team should have a designated team supervisor. This supervisor is responsible to assure:

- Proper protocol is followed in contacting local civil and health authorities in each cluster
- Standard procedures are followed to ensure quality data collection in all components of the survey
- Consent is obtained from participants and that potential survey subjects are aware of their right to refuse participation in the survey and to withdraw from the survey at any time.
- The survey manager is informed regularly regarding the progress of data collection in the field, as well as any problems so that solutions can be implemented in a similar manner by different teams.

5.2   Coordination and Communications

Adequate coordination and communications between the field teams and the survey manager are essential. In many countries the communication infrastructure outside of urban areas can be poor. It is recommended to provide each survey team with a field radio, mobile phone, or satellite phone to allow the survey manager to keep track of progress and solve problems in the field. Appropriate individuals should be notified of shipments of biologic specimens from the field to assure proper handling and

storage. In some circumstances it may be useful to provide teams with global positioning systems (GPS) to assist teams in finding selected clusters. Some satellite phones and other equipment can be used to record the altitude which can be used at the analysis phase of the survey to correct hemoglobin values.

5.3 Protocol

Each team must fully understand the survey procedures based on training and need to have a comprehensive protocol describing each step of field work and contingencies for dealing with problems, such as equipment failure or supply problems. The protocol should include clear instructions on handling and shipping completed survey forms and specimens. Some considerations in designing the survey are described below.

5.4 Recruitment of Survey Teams

The composition of the survey team is important in ensuring that the work is performed systematically and with good quality. Personnel recruited or assigned responsibility for the survey should be able to focus exclusively on the activity. Each survey team should have one individual designated as the "team supervisor." The team supervisor's role is to assure that clusters selected are actually surveyed, to visually verify that all forms are completed correctly, and the collection of specimens and other information is performed correctly. The number and types of other team members will depend upon the survey protocol. For the collection of biological specimens, a laboratory technician will need to be identified. It is important to develop a clear list of responsibilities of each team member and to communicate these within the first few days of training. It is helpful to have checklists in the field as reminders of roles and specific duties.

The number of teams to perform the survey will depend on a number of factors, including the number of clusters selected and the span of time to complete the survey. At one extreme a single team could assess every cluster, which would most likely increase the level of consistency in the way data are collected, however it may take a long time to complete the survey. At the other extreme there could be a different team for each cluster which would likely result in the survey being completed in a short period of time but potentially less consistency in data collection. To assure consistency in data collection, the fewest number of teams should be trained to collect data in a reasonable amount of time. Box 5.1 poses some questions concerning the number of survey teams and number of clusters.

Box 5.1 Survey team Calculations.

How many survey teams?   _____

How many clusters are to be surveyed nationwide?   _____

Average number of clusters to be surveyed per team?   _____

Factors that might influence the number of teams and number of clusters to be surveyed per team in Box 5.1 include the average amount of time a team will spend in a cluster and the average amount of time it takes for teams to travel from cluster to cluster. Our experience with micronutrient surveys collecting biologic specimens is that it generally takes 1 day to assess 10 households in a cluster and 2 to 3 days to assess 30 households within a cluster. Travel time between clusters can vary dramatically between countries and within countries depending on the size of the country and transportation infrastructure. Please provide estimates of these times in Box 5.2.

Box 5.2 Estimates of Survey Duration.

On average, how long would it take a team to survey one cluster?   _____ day(s)

On average, how many days of travel are there from one cluster to the next?   _____ day(s)

Add the two above averages together: _____ days

Multiply the above number by the number of clusters each team is expected
to survey   _____ days

Estimate the amount of time it will take to complete the survey
  taking into account weekends and holidays   _____ days

5.5 Pilot Testing

Pilot testing should be performed on all aspects of the survey. The questionnaire should be translated into the local language and tested. Pilot testing is useful to estimate the amount of time it will take to complete the survey in each cluster and to identify any potential problems with the survey instruments and protocol. The pilot testing should be undertaken in conditions similar to the field to simulate the actual data collection. Questionnaire validation and other (pilot) community-level training activities should take place in places different from those selected for the survey. Following the pilot test, all survey teams should convene and discuss the experience and modifications made, if necessary, to the protocol.

5.6 Training team members

Training of the team is an extremely important aspect. Training generally entails having documents that provide details on data collection, processing, storage, and shipping. A training schedule should be designed and those who are going to perform the training need to be identified early on for assisting in producing the training materials. It is recommended that an extra team be trained in case someone is unable to perform the field collection. Generally the training would include having in-class presentations over the various aspects of data collection followed by a test field collection experience. After the field experience, the team reassembles and discusses the field aspects. Appendix 7 provides guidelines for interviewing participants.

5.7 Development of Survey Instruments and Forms

The survey instruments should be as concise as possible while addressing the primary objectives of the survey. The major agencies responsible for the survey should be involved in the development of survey objectives and in proposing indicators and questions for the survey. The questionnaire will depend upon the indicators selected, but may include one or more of the following: demographic information; socioeconomic information; knowledge, attitudes and practices (KAP); and information related to the collection of specimens. At times it may be necessary to conduct qualitative interviews regarding selected topics prior to the cross-sectional survey to develop appropriate closed-ended questions.

While it may be tempting to collect information on many different characteristics, it is important to remain focused on questions that will provide the most relevant information based on survey objectives for assessing the current state and for future planning. For each question, thought should be given as to how the results of the question would be used, whether analysis of the question can potentially impact overall program management, be used to improve the health of the population, and precisely how the information would be presented in a table. We strongly recommend that countries use a questionnaire similar in design and wording as the UNICEF MICS and DHS. The UNICEF MICS questionnaires are available in English, Spanish, French, and Russian (www.childinfo.org). Standard methods for analyzing the data and tables are provided in the MICS documentation. Using the same or similar wording in the questions and similar tables for presenting results will allow for comparison within and between countries. Appendix 3 presents a sample questionnaire modified from the UNICEF MICS as an example of the type of questions that may be included as part of a micronutrient survey.

5.8 Other survey forms and documents

A number of additional materials will need to be developed to support the implementation of the survey and to monitor the progress of the fieldwork. Forms to accompany biologic and other specimens collected in the field and shipped to the laboratory would need to be developed. A comprehensive manual for field staff that provides guidelines for the survey would need to include detailed information on conducting interviews and measurement technique, information on each question, including the range and definition of responses. It is best if the manual is used in all stages of training, pilot field work, and in the field for the duration of the survey. This will help ensure a high degree of standardization and consistency, especially when several survey teams are involved with the survey.

5.9 Equipment and Supplies

Equipment and supplies are often not considered early enough in planning for a survey and can end up being a bottleneck that delays fieldwork. It is very important to develop a complete listing of all supplies needed with the number of items required (add approximately 10% to the number of items to order to assure adequate supplies). It is recommended that supplies be ordered at least six months prior to the training and field implementation. Table 5.1 provides an initial listing of supplies, although this would need to be modified depending upon which indicators are to be assessed and whether blood is

Table 5.1 Partial field Equipment and supply needs

Item to be collected/tested	Equipment/Supplies needed
General Supplies	Questionnaires Consent forms (if required) Clip boards Pens or pencils Survey manual Local calendar Map of survey areas
General biologic specimen materials	Disposable surgical gloves (different sizes, depending on make-up of team members) Biomedical waste disposal bags and hard-shell containers
Serum Collection (Venipunture)	Vacutainers (anticoagulant depends on specimens to be analyzed) Tube labels Tube racks Permanent ink pens Sterile disposable needles Butterfly needles (for small children) EPI cold boxes with frozen packs Bandaids Dry gauze pads Alcohol swabs (or cotton balls and alcohol) Tourniquets
Serum Collection (Capillary blood collected by finger stick)	Microtainers (anticoagulant depends on specimens to be analyzed) Tube labels Tube racks Permanent ink pens Sterile disposable lancets Bandaids Dry gauze pads Alcohol swabs (or cotton balls and alcohol) Container for disposal of biological samples and accessories
Dried Blood Spots from a finger stick	Sterile disposable lancets Filter papers Alcohol swabs (or cotton balls and alcohol) Band-aids Dry gauze pads Ziploc bags Silica gel sachets EPI cold boxes with frozen packs
Hemoglobin	Hemocue^{TM} or other equipement to measure hemoglobin (in addition to supplies for blood collection)
Urinary iodine	Disposable cups for collecting specimens Screw-capped tubes for urine storage and transportation Disposable pipette for transferring urine from cup to tube Tube labels Tube racks Cardboard with styrofoam-insert boxes Mailing/shipping labels Permanent ink pens for labels Sealable plastic bags
Iodized Salt Rapid test of iodine in salt Salt samples for titration (optional)	Rapid test kits (available from UNICEF); one vial can test approximately 50 salt samples Tube, bags, or packages for salt samples to be sent to a central laboratory for salt iodine titration analysis
Other Survey Equipment	Scales (for measuring weight) Height/length boards Other equipment as needed

collected from finger stick or by venipuncture. If laboratory tests are to be performed within the country, it is important that all necessary equipment and reagents for the laboratory be obtained.

Prior to going to the field each team should complete an inventory to ensure they have adequate supplies. All electronic and mechanical equipment should be properly tested to assure they are accurate and in working condition. Appropriate testing of some equipment will need to be performed on a routine basis in the field. Backup devices should either be with each team or available at a central site.

5.10 Logistics

A very time-consuming aspect of cross-sectional surveys is the logistics. This would include the ordering of all equipment, organizing pilot studies, organizing the training, and the actual field collection issues of vehicles, drivers, other forms of transportation, and accommodations. Having a person familiar with the administrative aspects of these types of arrangements is important to the overall success of a survey. This person is generally in addition to the survey manager/director.

5.11 Transportation and Lodging

The number and types of vehicles needed to perform the survey need to be determined early on and will depend upon the terrain, number of personnel on the survey team, the equipment, and security needs. In some settings four wheel drive vehicles will be necessary while in others a mini van will suffice. Lodging for survey teams is usually arranged prior to the field implementation.

5.12 Disposal of Contaminated Materials

All biomedical waste should be handled, packaged, labeled or color-coded, transported, and decontaminated in accordance with the requirements within the country. Usually, approved methods of decontamination of biomedical wastes are autoclaving and incineration. In some countries, blood and urine may usually be discarded either by carefully decanting into the sanitary sewer with 10% household bleach, by autoclaving, or incineration.

5.13 Budget

The cost of the survey will depend to a great extent on the sample size and expense of laboratory tests. As a general rule, doing interviews and performing hemoglobin and urinary iodine tests in a 30 cluster survey with around 20-30 households per cluster will cost around $120,000 USD to $150,000 USD, or in the range of $120 USD to $160 USD per household. If expensive serologic tests are performed the costs can increase dramatically. There is a need to balance the number of households and individuals to survey with an acceptable level of precision against the cost of performing the survey. This usually means there needs to be some tradeoffs, such as either reducing the overall sample size, eliminating some tests, or performing expensive tests on a sub-sample.

Chapter 6
Data Entry, Cleaning, and Analysis

The careful entry of survey data, cleaning of the data, and proper analysis are important. Similar to efforts to assure quality in the collection of data and in the handling and processing of specimens in the laboratory, adequate planning and procedures apply to the way data are entered into the computer and analyzed. This chapter discusses issues on data entry, cleaning, and analysis of data.

6.1 Data Entry

The data entry system must be decided upon prior to the start of the survey. Some important issues are which software program to use for data entry and the identification of an individual to develop the data entry system. Common programs used for data entry are Epi Info[6] (www.cdc.gov/epiinfo), Epi Data (www.epidata.dk), and CSPro (www.census.gov/ipc/www/cspro/). Other programs can be used for data entry, but as a general rule, the data entry system needs to be developed within a relatively short time period. It is best to use a program that could easily be modified by others should the primary developer be unavailable.

Three possible ways to have data entry performed are:

- *As the data are collected*: Enter the data onto computer while the participant is present, this allows for the immediate double-checking of suspect data and the ability to re-measure a participant. This method also identifies errors in completing the forms and would require each team to have a portable computer, electricity, requires training of the survey personnel for this purpose, and may increase the cost of the survey. Personal digital assistants (PDAs) are becoming more widely used for collecting data in surveys.

- *Enter data at the end of the day by the survey team*. While not as flexible as option 1, this approach could also allow for correction of erroneous data by allowing the team to return to a cluster.

- *Enter data at central location.* This method has the advantage of having a few experienced data entry personnel performing data entry, usually with fewer errors. This approach makes it difficult to correct errors due to incorrect information written on the forms. Rapid data entry allows survey managers and team supervisors to identify erroneous data collection procedures early in the survey which allows corrective action and we therefore recommend that no more than one week should pass between data collection and data entry.

A data dictionary should be developed that defines each variable in the database with its acceptable values (an example shown in Table 6.1). Ideally, data entry should perform error checking as data are entered.

When data are collected on paper forms, it is strongly recommended that the data be entered two times to identify data entry errors, a process referred to as "double data entry." While double data entry requires time and resources, the benefit of having as accurate a data set for analyses as possible is well worth the effort.

In many studies the questionnaires are first entered into the computer and later the results of laboratory analyses added to the files. The same rigor in which the questionnaires were entered should be applied to the data entry of laboratory results.

Table 6.1 Example data dictionary

Variable	Variable Name	Variable Type	Variable Width	Values/Notes
Participant ID no.	ID	Numeric	3	001-900
Cluster number	CLUSTER	Numeric	2	1-30
Age in months	AGE	Numeric	2.1	6.0-59.9 months
Date of birth	DOB	dd/mm/yyyy		
Sex	SEX	Numeric	1	1=Male, 2=Female
Date of Survey	SURVEY	dd/mm/yyyy		15/06/2004-20/08/2004
Hemoglobin	HB	Numeric	2.1	4.0-18.0
Urinary iodine	UI	Numeric	4.1	0.0-1000.0
Iodine levels in salt based on rapid test kit	IODINE	Numeric	2	0,7,15,30

*Note: these may not be correct minimum and maximum values for use in populations living at high altitudes

6.2 Data Cleaning

After correcting any data entry errors by comparing double-entered data, further data cleaning is performed to identify potentially erroneously recorded data which usually cannot be verified and corrected. This usually means performing a frequency of every variable to assure that the values are within an acceptable range, which should be defined in the data dictionary (Table 6.1). For example, individual ID numbers are usually unique and should occur only once in a data file - if there are duplicate ID numbers, it could be that: one questionnaire was entered two times; two different individuals were assigned the same ID number; or one of the two was entered incorrectly.

Logical errors should be investigated. Examples include:

- Assuring that the date of birth cannot be after the date the individual was surveyed
- A calculated age (calculated from the date of survey and date of birth) is similar to the stated age (the age as stated verbally)

Any errors found should be corrected or deleted from the database and the cleaning process repeated until the data are considered "clean." The number of missing responses for each variable should be investigated. If there are a large number of missing values, make sure that these are not a result of data entry.

6.3   Data Analysis

The analysis of data should take into account the complex design of multi-stage cluster surveys. Commonly used computer programs that allow such analyses include Epi Info[7] (www.cdc.gov/epiinfo), SAS version 8.0 or later (www.sas.com), SPSS with the optional *SPSS Complex Samples* module (www.spss.com), Stata (www.stata.com), and Sudaan (www.sudaan.com). All calculations should be considered as estimates of the "true" values for the target population. Ninety-five percent confidence intervals around prevalence and coverage estimates provide a range of values in which the "true" proportion is likely to be "captured."

In the interpretation of data, it is important to remember that sampling errors, measurement errors, and the skill of the survey team members influence survey results. In general, if a stratified survey is performed, prevalence estimates are provided for each stratum as well as a national estimate. Information collected at the cluster level is usually not presented in a survey report but they may be useful to identify geographic areas where the prevalence of micronutrient deficiencies are much higher than expected or the coverage of interventions much lower than expected. Therefore, further investigation into clusters where problems appear to be present may be warranted. There are differences in how data are analyzed depending upon whether or not the PPS methodology and/or stratification were used and described in the next two sections.

6.3.1 PPS Surveys

With a single PPS survey where sample weighting is frequently not necessary, it is relatively straightforward to calculate a proportion. Consider iodized salt use in a single PPS survey - all that is

needed is to count the number of salt samples found to be adequate divided by the number of salt samples tested, which could easily be calculated by hand. For example, if 300 households had salt available for testing and 157 had adequately iodized salt, then the proportion of households with adequately iodized salt would be 157/300 = 52%. If a single school-based PPS survey was performed and 451 children out of 600 had a UI < 100 µg/L, then the proportion would be 451/600 = 75%.

While the calculation of the proportion for PPS surveys is straightforward, the calculation of 95% confidence intervals is more complex. The 95% confidence interval is an important part of presenting the results because it provides a range that, with 95% confidence, captures the "true" proportion. Also, the width of the confidence intervals provides a measure of the precision of the survey; the narrower the confidence limits, the greater the precision. In comparing one area to another or the results of two surveys performed at different times in the same area, the confidence intervals can assist in determining whether the difference between two prevalence estimates is significant (note that a statistical test taking into account the survey design could also be applied).

Given equal sample sizes, confidence intervals for PPS surveys are usually wider than those using simple random sampling. This is because in PPS the first stage of selection is the cluster, and the second stage of selection is individuals and/or households. It is beyond the scope of this manual to explain this concept further. There are a number of introductory survey statistics textbooks that provided these details.

Epi Info Version 6 (DOS) has a module for analyzing complex survey data called *Csample*. This program can calculate correct confidence intervals for cluster survey data. Additional information on use of Csample can be found in the Epi Info documentation. The Windows version of Epi Info (starting with version 3.0) has commands in the **Analyze Data** module that can take into account complex sample designs. The commands are **Complex Sample Frequencies**, **Complex Sample Tables**, and **Complex Sample Means**. An example using real data from a district in a country using the DOS version of Epi Info is described next.

6.3.1.i Example of analyzing PPS survey data using Csample

In this example, thirty schools were selected by PPS, and within each school, an average of 12 students had urine samples collected. A variable called UILT100 was created that dichotomizes UI into groups, where an UI <100 µg/L was coded as a "1" and ≥100 µg/L coded as a "2". After reading the Epi Info data file (a ".REC" file), the second Csample screen is shown in Figure 6.1. The **Main** variable (UILT100) is that which identifies whether or not the UI was less than 100 µg/L. The other important variable is the **PSU** (primary sampling unit), which in a cluster survey is the variable that identifies the

clusters. In this example, the variable is called `cluster`. The other parts of the screen (**Strata**, **Weight** and **Crosstab**) are left blank. The results of the analysis are shown in Figure 6.2. The interpretation of the output is that only 8.6% of the urine specimens had an iodine level <100 µg/L and the 95% confidence limits are 3.8%, 13.4%. More details on the output in Figure 6.2 are provided below:

`Obs`	The number of observations; in the example where UILT100 = 1, there were 31 children with a low urinary iodine
`Percent V`	The "vertical" or column percent; in the example where UILT100=1, 8.587% (31/361) had a low urinary iodine (UILT100=1)
`SE%`	The standard error
`LCL%`	The lower confidence limit in percent; in the example where UILT100 = 1, the lower confidence limit is 3.793%
`UCL%`	The upper confidence limit in percent; in the example where UILT100 = 1, the upper confidence limit is 13.382%
`Total Obs`	The total number of observations with valid data
`Design eff.`	The design effect

Figure 6.1 Example of initial Csample screen from Epi Info 6.04 (DOS version)
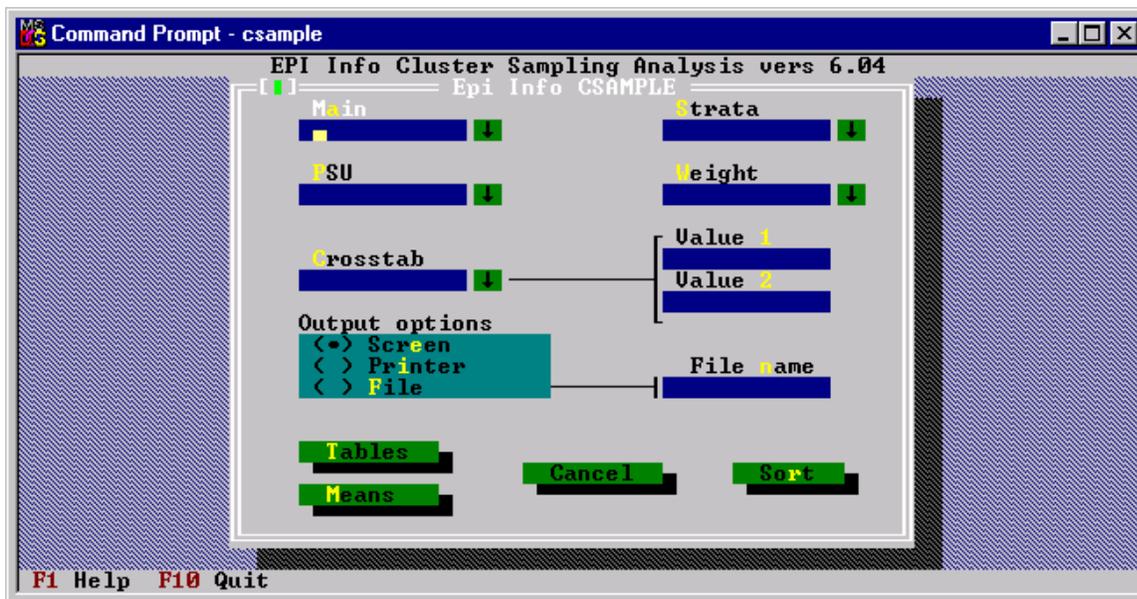
The design effect (DEFF) was 2.75, which would indicate that there was moderate variation in the proportion of individuals with low UI values from school to school. In this example, the proportion of students with low UI values by school ranged from 0% to 50% (data not shown).

If the cluster design of the survey had been ignored (i.e., an analysis ignoring the complex sample design and analyzed as though the data were collected using simple random sampling), the proportion of urine specimens with low values (<100 µg/L) would be the same (8.6%), but the confidence intervals would be too narrow (5.7%, 11.5%).

Figure 6.2 Example of output from Csample module of Epi Info 6.04 (DOS version)

```
CTABLES COMPLEX SAMPLE DESIGN ANALYSIS

 Analysis of UILT100
UILT100
|          |Total     |
|----------|----------|
|1         |          |
| Obs      |        31|
| Percent  V     8.587|
| SE%      |     2.446|
| LCL%     |     3.793|
| UCL%     |    13.382|
|----------|----------|
|2         |          |
| Obs      |       330|
| Percent  V    91.413|
| SE%      |     2.446|
| LCL%     |    86.618|
| UCL%     |    96.207|
|----------|----------|
|Total Obs |       361|
|----------|----------|
|Design eff.|    2.752|
 ----------------------

  Sample Design Included:
  ----------------------
  Sampling Weights—None
  Primary Sampling Units from CLUSTER
  Stratification—None

  839 records with missing values
```

6.3.2 Stratified PPS Surveys

If the overall survey were divided into different geographic areas ("strata"), and a separate PPS survey performed in each area, this is referred to as a *stratified PPS survey*. The previous section is applicable to the analysis of each stratum separately; however, usually an overall estimate is desired combining all strata. In order to derive a correct overall estimate, sample weights most likely need to be applied to each stratum to account for differences in population size in each. In this section the weighting of data will be shown by two different methods; the first will be calculating the estimates by hand and the second will be the use of Epi Info to perform a *weighted* analysis.

For example, say a country performs a stratified PPS survey; one survey in the capital area (Region A); one in the mountainous region (Region B); and one in the rest of the country (Region C; Table 6.2). Table 6.2 shows that 62.9% of the population lives in the capital area, 21.6% in the mountainous area, and 15.5% in the rest of the country.

Table 6.2 Example of weighted analysis performed by hand

Region	Population Distribution		Urine Samples Tested Distribution		Low UI	
	n	%	n	%	n	Prevalence of low UI (%)*
A	372,978	62.9	334	34.5	112	33.5
B	127,841	21.6	324	33.5	185	57.1
C	92,117	15.5	309	32.0	119	38.5
Total	592,936	100.0	967	100.0	416	-

*Number with low UI value divided by the number of samples tested

The number and percent of UI samples collected in each region are shown in columns 4 and 5, respectively. The last two columns on the right are the number of urinary iodine values <100 μg/l and the prevalence of low UI by region. When combining results from the three strata, the differences in population size needs to be considered. An incorrect approach to estimating the percentage of the population with low UI values would be to sum up the number of individuals with low UI and divide by the number of samples tested (416 / 967 = 43.0%). This is the correct percentage of the number of *samples* with low UI, but is not a correct estimate of the percentage of the *target population* with low UI. To determine the weighted prevalence of low UI for the entire population, it is important to take into account the size of the population in each region. For this example, we will use the percentage of the population in each region. The correct overall population estimate would be:

[(62.9% x 33.5%) + (21.6% x 57.1%) + (15.5% x 38.5%)] / 100 = 39.4%

In the above calculation, the percent of the population that lives in each region is multiplied by the percent of individuals with low UI and these values summed. The last step is to divide by 100, which provides the more correct weighted estimate of 39.4%.

The previous example depicts how to perform weighted analyses by hand and is provided to present the concept. The more common approach is to add sample weights to a data file and apply these weights in the analysis. For the following example the Epi Info software program will be used, but similar methods can be used to weight estimates in most statistical software programs. The steps to weight data require some calculations by hand and then some programming. First, the weights are calculated by hand. Using the example from Table 6.2, the first five columns are repeated in Table 6.3. The last column on the right is for the weights for each region. The weight is determined by dividing the percent of the population in each region by the percent of the sampled participant in each region. For example, for

region A, the weight is 62.9 / 34.5 = 1.823. Once these weights are calculated, then they need to be added to the data file. Each individual in the file from region A should have the weight 1.823. To do this in Epi Info's ANALYSIS program, you need to first create or DEFINE a variable and then give values to the new variable. An example is as follows:

```
DEFINE SWEIGHT #.###
IF REGION = "A" THEN SWEIGHT = 1.823
IF REGION = "B" THEN SWEIGHT = 0.645
IF REGION = "C" THEN SWEIGHT = 0.484
```

Table 6.3 An example of calculating weights for use in computer program

Region	Population		UI Samples Tested		Sample Weight
	n	%	n	%	
A	372,978	62.9	334	34.5	1.823
B	127,841	21.6	324	33.5	0.645
C	92,117	15.5	309	32.0	0.484
Total	592,936	100.0	967	100.0	-

Another acceptable approach to weighting the data is to divide the population in region by the number sampled in that region. For example, the weight for Region A would be 372,978/334 = 11,167.03. This calculated value can be thought of as follows: for every individual sampled for a urine specimen, they represented 11,167.03 individuals of the region's population. Weights could similarly be calculated for Regions B and C. Use of either sample weights in a complex sample computer program would provide the same estimates.

To have the analyses take these weights into account in Epi Info's Csample program, you need to provide the weight information in the dialog box (see Figure 6.1). Further details and examples can be found in the chapter on Csample in the Epi Info documentation.

6.3.3 Non-PPS Surveys

It may not always be possible to perform a PPS survey. For example, if clusters were selected using a simple random or systematic sampling methodology, and a sample of respondents interviewed in each cluster, the population size of each sampled cluster is required to correctly analyze the data, which must

be weighted. The approach to weighting is similar to that described in the previous section. The difference would be that the population size in each cluster surveyed would be used to calculate the weight.

6.4 Summary

This chapter describes issues related to data entry, data cleaning, and data analysis. These are important aspects of assuring good data quality in the development of the preliminary and final reports. Issues related to using programs that account for complex sample designs and weighted analyses were presented. Examples of the types of tables for a survey report are provided in Appendix 8.

Chapter 7

Development of Preliminary Report, Final Report, and Program Management

Analysis of data, producing preliminary and final reports, and using these results to improve the health of the population are important aspects in the survey process. The amount of time allotted to data analysis and report writing is frequently underestimated. Depending on the complexity of the survey, the final report may be 100 to 200 pages or more and take 6 to 18 months to complete. Because of the long time it usually takes to complete a final report, it is recommended preliminary report on the key survey outcomes being developed and used for program management within a few months after the completion of the survey.

The results of the survey should lead to a dissemination event which should include relevant groups within the country to consider the results of the survey and how these should influence intervention program planning and policy. It may be useful to have brochures on the key findings of the survey and slide presentations with the key findings. Follow-up documents might include long-term planning recommendation and policy documents to reduce disease prevalence and improve intervention coverage, and documents that perform trend analysis and compare the results of the survey with other sources of information.

In the following sections are more details on the preliminary report, final report, and other follow-up activities.

7.1 Preliminary Report

A preliminary report should be produced as soon as possible presenting key results, usually within a few months following the end of field collection, although this could be longer depending on the availability of laboratory results. This document could be used for advocacy and program management and is generally between three and 20 pages depending upon the complexity of the survey.

The Preliminary Report should include the following:

- Background and objectives of the survey: The major objectives of the survey; how the survey fits into the larger aspects of the national plan for micronutrient elimination; and institutions involved in the survey process and funding agencies.
- Abbreviated Methods section that would include items measured and collected in the survey and the survey methodology, which would include: Sample design; response rate; and processing of data. The definition of the indicators, such as the definition for anemia, iron deficiency, and vitamin A deficiency.
- Key results: Provide results of key indicators that can assist in planning purposes and also for advocacy.
- Conclusions and plan of action: What are the major findings and a note of caution that the data are preliminary and that a more complete report would be available in the near future.

7.2 Final Report

The completion of a comprehensive full report is essential. This final report serves many functions:

- Provides detailed results of the survey
- Allows others to evaluate the methods and quality of the survey results
- May serve as a guide for future surveys

    Frequently the final report may take six to 18 months to complete and this report should be shared with all interested agencies.   The report is generally divided into different chapters.   One way of organizing the report is described below; however, different ways of organizing the report can be used. An important decision that needs to be made in the development of the final report is whether it should present only the results of the survey or whether it should also include recommendations. In general, a report that presents results without recommendations can be completed in a shorter time period. Adding recommendations to the report may make the report more of a policy document which may need to be reviewed and approved by many individuals in different government agencies.

Executive Summary – This section presents a summary of the key findings and their implications on the national program with primary recommendations. This section is generally a few pages long.

Introduction – The introduction usually has information on the health effects of micronutrient malnutrition, the magnitude of the problem, and activities undertaken to eliminate micronutrient malnutrition in the survey area. Information on previous surveys in the survey area or nearby areas

should be included. The purpose of the survey described in the report should be clearly stated. Frequently some basic demographic information for the country is provided.

Methods – The details of the methodology should be presented. This would include describing the features of the survey methodology, e.g., stratification, primary sampling units, method of selecting primary sampling units, methods for selecting households, etc. Laboratory methods used in the analyses of specimens should be provided as well as which laboratories performed the analyses. The statistical methods used, such as statistical weighting, and the software used for data entry and analysis should be provided. Important here is to provide the reader with sufficient information to determine if a reasonable approach to the analyses of data were used. The target groups and the type of information and specimens collected in these groups are provided. Definitions used to define outcomes, such as hemoglobin cut-points to define anemia, the definition for vitamin A deficiency, and other conditions. The definitions are important because sometimes definitions may change over time and it is important to be absolutely clear concerning the exact definitions used. Do not assume that everyone reading the report will be an expert in micronutrients.

Results – The first part of the results should provide information on the quality of the survey, such as response rates and frequency of key variables with missing or incorrect values. This will provide the reader with some information to allow them to form an impression on the quality of the data, and therefore the level of confidence to place on the results. The next part is to provide a description of those who were surveyed, such as the number of individuals by age and sex categories. The final part provides the detailed tables by topic, for example:

- Iron Deficiency and Anemia
- Vitamin A
- Iodine Deficiency

   Examples of tables are provided in Appendix 8.

Conclusions – The most important findings should be provided. In addition, any weakness or problems encountered in data collection and analysis should be provided with recommendations on how to improve future surveys. If it has been decided to include recommendations into the final report, they would usually be presented in this section.

Acknowledgements – Acknowledge individuals and institutions that assisted in the design, implementation, and analysis of the survey.

Appendices – Appendices should include the questionnaires used in the survey and any other documents that might have more details on the methodologies used to design the survey and training materials.

7.3 Additional Reports

In addition to the final report, there may be other reports developed. These would include reports on trend analysis, comparison of the survey results with other sources of data, and more in-depth analyses. We recommend that these data files be made available to other researchers to perform more detailed investigations.

7.4 Dissemination

An important element is to share the preliminary and final reports with government agencies, institutions, donor agencies, NGO's, and the press. In many settings the release of the results is first shared with the key agencies and institutions, and then presented in a formal press conference by high-ranking government officials. These results should be shared with regional and provincial health authorities, especially if the survey included stratification of geographic areas. Frequently the longer the interval between completion of the field collection and the release of results, there is less interest, enthusiasm, and importance placed upon the results. There may be meetings that focus on specific topics, such as flour fortification.

It would be important to hold meetings with key stakeholders on policies to improve national intervention programs and, therefore, improve the health of the population. These meetings would usually entail the development of long-term planning (e.g, five-year plans) that would identify key individuals responsible for programs, provide timelines on improving intervention coverage, monitoring programs to assess coverage between cross-sectional surveys, and sufficient budgets.

Appendices

Appendix 1
Background on Micronutrient Deficiencies

The purpose of this Appendix is to provide an overview of the magnitude and consequences of micronutrient deficiencies. While experts on micronutrients will be familiar with this information, those involved in certain aspects of a micronutrient survey may not. This chapter also summarizes the importance of assessing micronutrient deficiencies and their interventions.

A1.1 Iron Deficiency (ID), Anemia, and Iron Deficiency Anemia (IDA)

Iron deficiency is prevalent in both industrialized and developing countries. In the former, severe iron deficiency is the main cause of anemia. In poor populations, diets may be monotonous and based on foods low in iron and high in iron-absorption inhibitors. Populations living under these conditions frequently have low iron stores, particularly young children and pregnant women. In addition to iron deficiency, anemia is also associated with other nutrient deficiencies (folic acid, vitamin A, B12), malaria, intestinal parasitic infestations (especially hookworm, schistosomiasis and amoebiasis), and chronic infections such as HIV, cancer, and tuberculosis.[8]

A1.1.1   Global prevalence of ID, Anemia, and IDA

Iron deficiency (ID) is the most common nutrient deficiency and anemia, as an indicator of iron deficiency, affects nearly 2 billion people worldwide, or about a third of the world's population.[8] Overall, it is estimated that worldwide 39% of preschool children and 52% of pregnant women are anemic, the majority living in developing countries.[8] Many school-aged children, adults (male and female), and the elderly are also anemic. Iron deficiency can affect all age groups and presents a major hurdle to national development.

A1.1.2   Consequences of ID, Anemia, and IDA

ID has profound negative effects on human health and development. In infants and young children, functional consequences include: impaired immune function; slowed psychomotor development, coordination, and scholastic achievement; and decreased physical activity levels.[8] In adults, iron deficiency results in fatigue and reduced work capacity. In pregnant women, iron deficiency anemia is associated with an increased risk of maternal mortality and morbidity, perinatal mortality and morbidity, and strongly associated with prematurity and intrauterine growth retardation.[8]

A1.1.3   Interventions for IDA

Common measures to prevent iron deficiency include: iron fortification of commonly eaten staple foods, selected condiments, and complementary baby foods; iron supplementation; and general public health measures to prevent parasitic diseases and common infections. At present, in most countries the primary measure to control iron deficiency and anemia consists of providing iron supplements to pregnant women and, less frequently, to young children. An increasing number of countries have iron fortification flour programs.   For   additional   information   on   the   Flour   Fortification   Initiative   see www.sph.emory.edu/wheatflour/main.htm.

A1.2 Vitamin A Deficiency (VAD)

Vitamin A deficiency (VAD) is a major public health problem with the most vulnerable being preschool children and lactating and pregnant women in low-income countries.[2] Women in endemic vitamin A-deficient areas should receive a vitamin A supplement following delivery. [2] The need for vitamin A increases during lactation to replace vitamin A losses in breast milk. In children, VAD is the leading cause of preventable visual impairment and blindness. An estimated 250,000 to 500,000 children become blind every year due to VAD, with around half of whom die within a year of becoming blind.[9]

A1.2.1   Global prevalence of VAD

WHO has estimated that vitamin A deficiency is a public health problem in 96 countries.[2] Africa has the highest prevalence of VAD while the highest numbers of clinically affected are in South-East Asia. Among children under 5 years of age affected by VAD, 3 million have signs of xerophthalmia. Most of the estimated 140 and 250 million children affected by VAD do not have clinical manifestations but are at greater risk of developing severe infections and mortality.[2]

A1.2.2   Consequences of VAD

In addition to blindness, VAD significantly increases the risk of severe illness and death from common childhood infections, particularly diarrheal diseases and measles. In communities where VAD exists, children are, on average, 23% more likely to die and 50% more likely to suffer complications as a result of measles infection.[2] In women, VAD may be an important factor contributing to maternal mortality and poor pregnancy and lactation outcomes.[2] VAD is also likely to increase vulnerability to other disorders, such as iron deficiency anemia. In VAD-endemic countries, pregnant women often experience deficiency symptoms, such as night blindness, that continues into the early period of lactation.[2]

In some countries of South-East Asia, the prevalence of night blindness has been reported to be as high as 10-20% in pregnant women.[2] For nursing infants, the breast milk they receive from deficient mothers is likely to contain insufficient vitamin A to build or maintain vitamin A stores.[2]

A1.2.3   Interventions for VAD

Strategies for controlling VAD aim to provide an adequate intake through a combination of breastfeeding, dietary improvement, supplementation, and food fortification. Protection, promotion and support of breastfeeding are essential components in VAD prevention programs. Dietary improvement is an important complement to supplementation and fortification. The challenge is that dietary improvement is usually difficult to achieve in the short term, but in many countries, home gardens with vitamin-A rich fruits and vegetables, particularly for vulnerable families, has been promoted as a long term solution.

The periodic use of high-dose vitamin A capsules is a highly effective means of improving vitamin A status. Immunization programs provide a channel for the delivery of vitamin A supplements. Food

fortification with vitamin A is becoming more common and this approach is increasingly feasible in countries.

A1.3 Iodine Deficiency

Iodine deficiency constitutes the single greatest cause of preventable brain damage in the fetus and infant, and of retarded psychomotor development in young children. It remains a major threat to the health and development of populations the world over. [40]

A1.3.1 Global prevalence of Iodine Deficiency Disorders (IDD)

Knowledge of the global magnitude of iodine deficiency has improved considerably since 1990. Iodine deficiency is now identified as a significant public health problem in 130 countries, with an estimated 2 billion worldwide with insufficient iodine intake, or 24% of the world's population. The most affected regions, in decreasing order of magnitude, are Europe (57%), Eastern Mediterranean (54%), Africa (43%), South-East Asia (40%), Western Pacific (24%), and the Americas (10%). [10]

A1.3.2 Consequences of Iodine Deficiency

Iodine deficiency results in goiter, stillbirth, and miscarriages, but its most devastating toll is mental retardation, deaf-mutism, and impaired learning capacity.[40] While cretinism is the most extreme manifestation, of considerably greater significance are the more subtle degrees of mental impairment that lead to poor school performance, reduced intellectual ability, and impaired work capacity.

A1.3.3 Interventions for IDD

The main intervention strategy for iodine deficiency prevention and control is universal salt iodization (USI), which was established as a World Summit for Children goal in 1990 and adopted by the World Heath Assembly in 1993. Salt was chosen as the food item to fortify with iodine for a number of reasons. First, salt is widely consumed by most populations, and second, the costs of iodizing salt are low, around five US cents per person per year.[40] In high-risk areas, where populations cannot be reached by iodized salt, an alternative is to administer iodine supplements with a focus particularly on women and children.

In the early 1980s few countries were known to be affected by iodine deficiency with only a handful having iodine deficiency control programs, usually iodized oil supplementation. Over the last decade, extraordinary progress has been made in increasing the number of people consuming iodized salt. In 1990 only 46 countries had salt iodization programs, and by 1998 the number had increased to 93, of which more than 80% have legislation requiring iodized salt.[40] Overall, more than two-thirds of households in now consume iodized salt.[11]

Appendix 2
Micronutrient Indicators

This Appendix provides more details on the indicators of micronutrient malnutrition and intervention programs. Many of the indicators for micronutrient malnutrition, such as serum retinol, hemoglobin, and serum ferritin, are affected by inflammation due to an acute or chronic condition. Indicators of inflammation are described in this Appendix.

A2.1 Vitamin A Deficiency (VAD)

Different indicators for VAD are described next. WHO has recommended that at least two biologic parameters, i.e., night blindness, biochemical, or histological indicators, be used to determine whether VAD exists as a public health problem rather than relying solely on a single indicator.[12] Alternatively, one biologic indicator and at least four (two of which are nutrition and diet-related) demographic and ecologic risk factors: high infant mortality, low immunization coverage, poor infant feeding practices, low dietary intake, high prevalence of diarrhea, low education of women, and inadequate supply of safe water. (Note: the WHO VAD document gives more details on the exact cutoffs for the demographic and ecologic risk factors.) The most likely biochemical indicator of VAD to be collected in a cross-sectional survey is serum retinol and described in more detail below.

A2.1.1 Serum retinol

Serum retinol is the key indicator to use in tracking progress towards the elimination of VAD.[13] Serum retinol values can reveal marginal vitamin A deficiency before the deficiency is severe enough to cause clinical manifestations. Serum retinol is affected by inflammation and where possible, efforts should be taken to collect information on infection status. As is the case with any biochemical parameter, it is essential that sample collection, preparation, storage, transport, and laboratory analysis be considered in the planning stage of the survey. Most commonly, retinol is measured from serum samples that are separated by centrifuge from whole blood collected by venipuncture or finger stick and stored in tubes

impermeable to light and refrigerated until laboratory analysis. [14] However, these procedures are often difficult to implement in remote field conditions because of the need for a centrifuge and refrigeration.

The most common and accurate method for measuring serum retinol has been to analyze serum by high-pressure liquid chromatography (HPLC). [15] This method has been adapted for use with blood spotted onto filter paper, such as the method developed by Craft Laboratories (Wilson, NC, USA). These dried blood spots (DBS) need to be stored in airtight plastic bags under cold chain conditions until they are analyzed. The laboratory analysis of DBS serum retinol has been shown to correlate very closely with conventional techniques.[16] [17] It is recommended that retinol be analyzed using HPLC with vigilant quality control. There has been significant variation in the results of retinol analyses conducted in different laboratories.[18] The preparation of DBS and serum samples for analysis requires different technical requirements, and while serum samples can be analyzed in many labs, at the current time, DBS analyses is performed in a limited number of laboratories worldwide. Whenever possible, serum retinol from serum specimens using HPLC is the recommended method. If serum samples cannot be collected, the DBS method could be considered as an option with a subsample having serum retinol performed. Interpretation of the prevalence of low serum retinol is presented in Table A2.1.

Table A2.1 Prevalence of serum values of vitamin A ≤0.70 µmol/l (≤20 µg/L) in children ≥1 year

Level of importance as a public health problem	Prevalence
Mild	≥2 to ≤10%
Moderate	>10 to <20%
Severe	≥20%

Source: WHO/NUT/96.10, *Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes*.

A2.1.2 Retinol binding protein (RBP)

Retinol binding protein (RBP) has an approximate 1:1 molar relationship with retinol and has been proposed as a surrogate indicator.[19] [20] [21] An advantage of RBP is that, as a serum protein, it is relatively stable compared to retinol. This relative durability and equi-molar relationship to retinol in serum has facilitated the use of RBP as a surrogate measure of retinol as an indicator of VA status.[22] [23]

There are several methods that have been developed to assess RBP. One test developed by the Program for Appropriate Technology in Health (PATH) based on an ELISA platform has been validated. The RBP-EIA developed by PATH is undergoing final field evaluation with specimens from at-risk populations, and is commercially available (Scimedx, Denville, NJ). The RBP-EIA has been optimized to use serum from both venous blood (collected by venipuncture) and from capillary blood (collected by finger-prick and stored as DBS). More information on the RBP-EIA is available

(http://www.path.org/technos/ht_rbp_eia.htm). At this time the recommendation is that the preferred methods for assessing vitamin A status is through serum retinol and that RBP may be a promising alternative once sufficient investigations have been performed. See also the report by Erhardt et al.[24]

A2.1.3 VAD clinical and morphologic indicators

While clinical or functional indicators of VAD are generally *not* recommended for routine cross-sectional surveys, they deserve mention. Clinical indicators of VAD include xerophthalmia which comprises a succession of eye signs that worsen as the depletion of vitamin A stores progresses compromising the integrity of retinal, conjunctival and corneal epithelia: night blindness (XN), Bitot's spots (X1B), corneal xerosis (X2), corneal ulceration (X3A), and corneal keratomalacia (X3B). Because clinical xerophthalmia is a rare event, even in areas where VAD is endemic, it is necessary to examine a large number of children in order to gain statistically precise estimates, and therefore its assessment is often prohibitive. The prevalence of night blindness in women during a pregnancy within the previous three years may be a useful indicator in populations with a local term for night blindness; a prevalence >5% would indicate significant VAD.[13] Efforts have been developed using dark adaptometry as a non-invasive approach to assessing VAD.

A2.1.4 VAD control program indicators (supplementation, fortification, and dietary diversification)

Indicators of control programs for vitamin A deficiency are described in the next two sections. These are indicators of vitamin A supplement coverage, vitamin A-fortified product coverage, and dietary diversification.

A2.1.4.i Vitamin A supplementation coverage

One of the most widely implemented interventions for the control of VAD is vitamin A supplementation. Most vitamin A supplementation programs are targeted to preschool children with high doses of vitamin A (usually from capsules). The distribution of vitamin A supplements may be delivered through routine health services or as part of national or sub-national "immunization days" or "child health" days, usually every 6 months. Vitamin A supplements may also be used therapeutically in the management of infectious diseases. In many countries vitamin A supplements are provided to post-partum women up to

eight weeks following delivery to increase stores of vitamin A and in turn, the concentration of vitamin A in breast milk. In order to estimate coverage, the percentage of children receiving at least one high-dose of vitamin A within the previous six months is often used as the primary indicator. For post-partum women, the proportion receiving a vitamin A capsule within eight weeks of their last birth could be determined, usually with a time period limit (e.g., among women having a birth within the previous three or four years).

A2.1.4.ii Fortified Vitamin A product coverage

Foods that can be fortified with vitamin A with relatively low cost include cooking oil, sugar, and flour. Countries with programs to reduce the prevalence of VAD through food fortification will usually want to assess the coverage of the fortified products. For monitoring fortification programs, it is appropriate to estimate the percentage of households with a vitamin A fortified product. If possible, the brand name, manufacturer, and whether the package is labelled as fortified should be collected.

A2.1.4.iii Dietary intake of Vitamin A

For large cross-sectional surveys on vitamin A status, as a general rule it is *not* recommended to include food frequency or 24 hour food recall modules to assess micronutrient status. If a country has specific interventions to increase the intake of certain vitamin A rich foods, then it might be useful to assess these specific foods. Some background information on vitamin A dietary intake is provided below.

Vitamin A deficiency is primarily caused by an inadequate intake of vitamin A in the diet. Until recently, it was believed that the consumption of plant sources of vitamin A, particularly green leafy vegetables (provitamin A carotenoids) would provide sufficient vitamin A to meet physiological needs. It is now recognized that these are less bioavailable and convertible to the form of vitamin A that is used by the body (preformed retinol) than previously thought. Animal foods, such as liver, milk, and eggs, provide the form of vitamin A that is readily available for physiological functions. In addition, β-carotene from yellow/orange fleshed fruits and vegetables is better absorbed than the β-carotene in green leafy vegetables.[25] Methods to measure vitamin A intake should include a distinction between the various sources of vitamin A in the diet.

Two techniques developed and used in the field for the assessment of vitamin A intake are the "24-hour Vitamin A Semi-Quantitative (VASQ)" and the "HKI Food Frequency Method" developed by Helen Keller International (HKI).[26]

A2.2 Iron Deficiency Anemia (IDA)

An important issue is to distinguish between anemia, iron deficiency (ID), and iron deficiency anemia (IDA). Anemia is usually defined by a low hemoglobin (Hb) concentration and in some settings is used as a proxy indicator for iron deficiency. In addition to iron deficiency, other factors that may cause anemia include:

- Malaria
- Blood loss due to infection (e.g., hookworm, shistosomiasis)
- Other causes of blood loss (e.g., hemorrhage in childbirth, trauma)
- Deficits in other nutrients (e.g., vitamin A, folic acid)

Iron deficiency anemia (IDA) is defined as individuals who are both anemic (based on low hemoglobin) and iron deficient (based on an indicator of iron status).   Recommended indicators of iron status are serum ferritin and serum transferrin receptor.

To understand the etiology of anemia, factors in addition to iron status may require investigation. For example, in areas where malaria and/or hookworm are known to be prevalent, it would be useful to determine infection status in survey participants to estimate the impact of these infections on prevalence of iron deficiency and anemia.

The relationship between iron deficiency (ID), iron deficiency anemia (IDA) and anemia is presented graphically in Figure A2.1. The level of overlap between ID, IDA and anemia will vary from population to population, and within populations, such as between different age groups, gender, and geographic areas depending on the severity of iron deficiency and the presence of other causes of anemia. In Figure A2.1, two populations with the same prevalence of anemia are presented. In setting A, the prevalence of ID in the population is high, as is the prevalence of IDA, while other causes of anemia are infrequent. In setting B, the prevalence of iron deficiency is not as widespread as in Setting A, but other factors, perhaps hookworm or malaria, are important causes of anemia.

The information on etiology of anemia is very important in designing intervention programs, as the most effective strategies to prevent and control anemia will be those which address the main factors implicated in its etiology.

Figure A2.1 Relationship between iron deficiency, iron deficiency anemia, and anemia
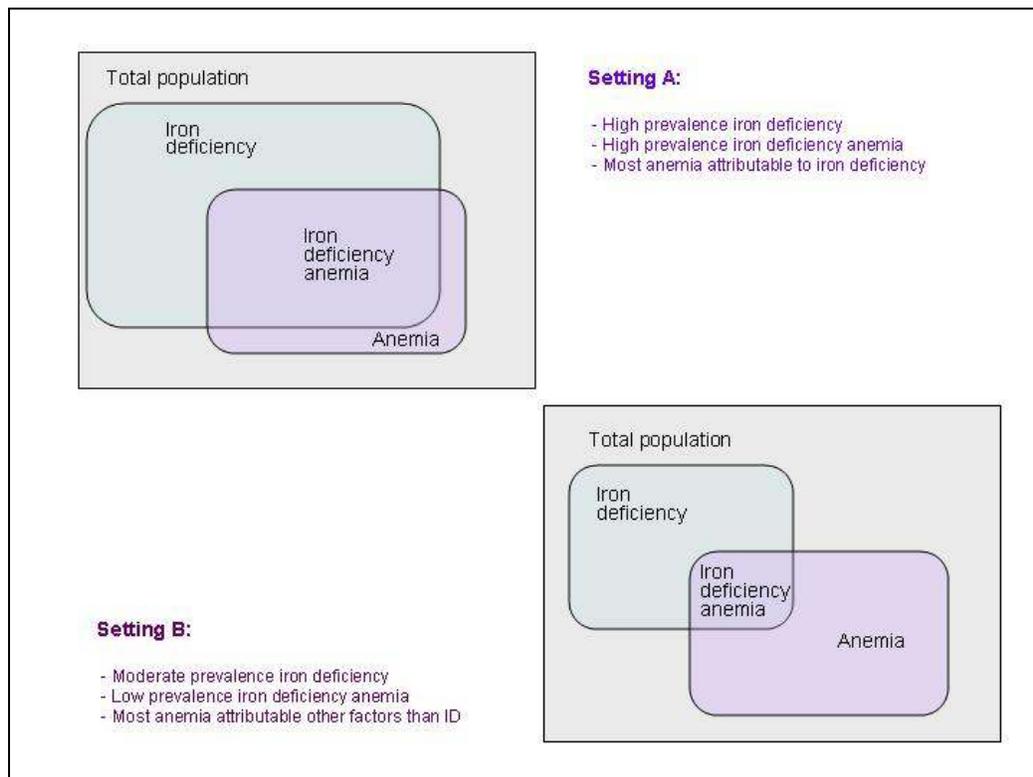
Adapted from Yip R. Iron nutrition status define. In: Filer IJ, ed. Dietary Iron: birth to two years. New York, Raven Press, 1989:19-36; and WHO/NHD/01.3

While it is recognized that assessment of factors associated with anemia may be necessary, it is not the focus of this manual. Consequently, this document does not describe procedures for the collection of stool samples for estimating the incidence and burden of helminth infection or the collection of blood to determine the presence of malaria. Some resources for the collection of information on helminth infection and malaria are presented below:

- WHO. Report of the WHO informal consultation on hookworm infection and anaemia in girls and women. WHO/CTD/SIP/96.1. Geneva: World Health Organization, 1994. http://www.who.int/ctd/schisto/96-1.pdf
- Centers for Disease Control and Prevention, Division of Parasitic Diseases. A good summary of hookworm infection with a section on lab analysis.
  http://www.dpd.cdc.gov/dpdx/HTML/Hookworm.htm
- WHO. "Hookworm Infection and Anemia: Approaches to prevention and control". Geneva: WHO, 1991.
- WHO. 'Bench Aids for the Diagnosis of Malaria Infections' (1999) WHO, ISBN: 92 4 154524 0
- 'Diagnosis of malaria: review of alternatives to conventional microscopy' (1999) Hanscheid T., Clin. Lab. Haem. 21, 235-245.
- Medical Laboratory Manual for Tropical Countries, Monica Cheesbrough Edition:2ND Edition. ISBN:0407004025, July 1987. Butterworth-Heinemann
- General resource from WHO
  http://mosquito.who.int/cmc_upload/0/000/015/867/epidemioligical_lg-en.pdf

A2.2.1 Hemoglobin as the primary indicator of anemia

Hematologic indicators for anemia include hemoglobin, hematocrit, mean cell volume, and red blood cell distribution width. It is recommended that hemoglobin be used for assessing anemia in cross-sectional surveys. For assessing the prevalence of IDA, it is recommended that countries collect data on hemoglobin and one biochemical test for iron deficiency.

The largest proportion of iron utilized for physiological functions is in the form of hemoglobin which accounts for almost two-thirds of total body iron.[8] To define anemia, WHO has established cut-off points for hemoglobin as outlined in Table A2.2. Hemoglobin values should be adjusted to take into account pregnancy, altitude, and smoking. The adjustments and the reasons they need to be made are described in more detail in two documents, one by UNICEF/UNU/WHO (2001) and INACG (2002). Preference was given to adjustments by UNICEF/UNU/WHO for Tables A2.2 and A2.3. These two documents adjust *cutoff points* for each individual; in this document, the approach provided below adjusts each *individual's hemoglobin value* and the cutoff value for each group does not change. The adjustments for pregnancy are in Table A2.3. If the exact trimester is not known, there is an overall adjustment for pregnancy.

Populations living at high altitudes where oxygen pressure is low have acclimated to their low oxygen environment and have higher levels of Hb, reduced oxygen saturation, and an increased production of red blood cells to ensure oxygen supply to tissues. Because of these factors, their Hb distributions are shifted to the right (upward). This physiological characteristic results in identification of fewer cases of anemia if cut-off points used to classify anemia for populations living at sea level are applied to those populations living at higher altitudes.[27] A correction for altitude was based on results from the Centers for Disease Control and Prevention (CDC)[28] and presented in Table A2.3.

Adjustments for current cigarette smoking are presented in Table A2.3. These adjustments are based on the *average number of cigarettes per day.*

A proposed scheme to classify the public health significance of anemia in a population is presented in Table A2.4. For populations with a prevalence of anemia ≥40%, the prevalence would be interpreted as being severe in terms of public health significance.

Table A2.2 Hemoglobin cutoffs to define anemia in people living at sea level

Age and sex	Hemoglobin cutoff (g/dL)
Children (males and females)	
≥0.5, <5.0 years	11.0
≥5.0, <12.0 years	11.5
≥12.0, <15.0 years	12.0
Nonpregnant females ≥ 15.0 years	12.0
Men ≥ 15.0 years	13.0

UNICEF/UNU/WHO (2001) and INACG (2002)

Table A2.3 Hemoglobin adjustment for pregnancy, altitude, cigarette smoking, and ethnicity

Trimester of pregnancy	Adjustment to individual hemoglobin value (g/dL)
First	+1.0
Second	+1.5
Third	+1.0
Trimester unknown	+1.0
Altitude (meters)	
<1000	No adjustment
≥1000, <1250	-0.2
≥1250, <1750	-0.5
≥1750, <2250	-0.8
≥2250, <2750	-1.3
≥2750, <3250	-1.9
≥3250, <3750	-2.7
≥3750, <4250	-3.5
>4250, <4750	-4.5
≥4750, <5250	-5.5
≥5250	-6.7
Cigarettes smoked per day	
<10	No adjustment
≥10, < 20	-0.3
≥20, < 40	-0.5
≥40	-0.7
Smoker, amount unknown	-0.3
Ethnicity	
African extraction	+1.0

Notes: The INACG document has adjustments by trimester; the UNICEF/UNU/WHO and INACG documents provide adjustments for pregnant vs. not pregnant. For altitude, the hemoglobin adjustments are based on the UNICEF/UNU/WHO document except for the highest two altitude values, which are based on the INACG document. A more accurate adjustment for altitude can be made based on the application of a formula.

Table A2.4 Proposed classification of public health significance of anemia in a population on the basis of prevalence estimated from blood levels of haemoglobin.

Category of public health significance	Prevalence of anemia
Severe	$\geq 40\%$
Moderate	20.0-39.9%
Mild	5.0-19.9%
Normal	$\leq 4.9\%$

Source: WHO 2001 (WHO/NHD/01.3)

At the individual level, severe anemia *in pregnancy* is defined as hemoglobin <7 g/dL; very severe anaemia *in pregnancy* is defined as hemoglobin <4 g/dL.

The recommended methods for measuring hemoglobin are the cyanmethemoglobin method and the HemoCue[TM] system (see Figure A2.2). The reference 'standard' for Hb measurement is cyanmethemoglobin.[29] The HemoCue[TM] is a portable dual-wave length photometer based on the laboratory procedure for the analysis of azide methemoglobin using disposable cuvettes coated with sodium azide (HemoCue[TM] AB, Angelholm, Sweden; www.hemocue.se).[30] Capillary blood from a finger prick is collected by capillary action in a cuvette, which is then placed in the photometer which displays the Hb level within one minute. Operating the HemoCue[TM] does not require specialized laboratory personnel and the instrument may be operated on four AA batteries, which make it particularly useful in the field. The procedures for specimen collection and analysis using the HemoCue require careful training and standardization of survey technicians.[31] [32]

Figure A2.2 HemoCue instrument

The HemoCue[TM] has been validated against traditional hemoglobin laboratory methods and found to have adequate accuracy and precision. Each machine costs approximately US$500 and the costs per cuvette is approximately US$0.50 when procured through UNICEF. The accuracy of hemoglobin measurement may be improved by first collecting 250-500 µl of blood in a microtainer, mixing the blood, and then performing a hemoglobin analysis from blood in the microtainer. While most of the field

experience in the use of portable hemoglobinometers has been with the HemoCue™ , there are other portable hemoglobinometers available produced by other manufacturers.

Finally, one important feature of Hb as an indicator of anemia is that its distribution among sub-groups of the population can provide information concerning its etiology. If low intake of dietary iron and/or low iron bioavailability is the main cause of anemia, then women and young children will be disproportianately affected compared to adult men. On the other hand, if other causes of anemia (e.g., malaria, infectious disease) are also common, then the Hb distributions of men will also be shifted to lower values.

A2.2.2 Indicators for assessing iron status

There are several tests available to determine iron status. WHO has recommended the use of serum ferritin (SF) and transferrin receptor (sTfR) for one-time assessments of iron-status, and serum ferritin for ongoing monitoring.[33] The following sections describe these two indicators of iron status.

A2.2.2.i Serum ferritin (SF)

Serum ferritin is the most specific biochemical test that correlates with total body iron stores. A low serum ferritin level reflects depleted iron stores and hence is a precondition for iron deficiency in the absence of infection. However, serum ferritin is also an acute-phase reactant and is elevated in response to infectious or inflammatory processes. Consequently, serum ferritin in the normal range reflects iron sufficiency in the absence of infections of inflammatory illness and interpretation of serum ferritin is problematic in populations in which the incidence of infection is high.

Serum ferritin cut-offs indicating iron depletion are presented in Table A2.5. The generally accepted cut-off level for iron depletion for most segments of the population using serum ferritin is <15 μg/l, while a cut-off of <12 μg/l is used for preschool children under 5 years of age.

A number of commerical assays are available for the assessment of serum ferritin. The costs per test depends on the kit, but is generally around US$8.

Table A2.5 Relative extent of iron stores on the basis of serum ferritin concentration; by age and sex

	Serum ferritin (µg/l)*			
	Less than 5 years of age		More than 5 years of age	
Iron Stores	Male	Female	Male	Female
Depleted iron stores	<12	<12	<15	<15
Severe risk of iron overload	-	-	>200 (adult male)	>150 (adult female)

Source: WHO 2001 (WHO/NHD/01.3) and modified as recommended by WHO/CDC 2005 (WD 105)
*Among those without an elevated acute phase protein

A2.2.2.ii Serum Transferrin Receptor

Serum transferrin receptors (sTfR) are found on cell membranes and allow iron-bound transferrin to enter the cell. When the iron supply is inadequate, there is an up-regulation of transferrin receptors to enable the cell to compete more effectively for iron. The number of membrane receptors is in proportion to the receptors found in plasma. An increase in sTfR levels is seen in patients with iron deficient erythropoiesis or iron deficiency anemia. The soluble sTfR seems to correlate well with the amount of receptor expressed at the cell membrane, which in turn reflects the cellular need for iron.[34] The sTfR increases with tissue iron deficiency and with increased erythropoiesis.[35] It does not appear to be elevated by inflammatory diseases[36, 37] and low biological and analytic variability has been reported.[38]

In controlled phlebotomy studies, the sTfR does not increase until iron stores are completely exhausted.[39] When SF falls below 12 µg/l, the sTfR begins to rise, roughly in proportion to the deficit in functional iron. As mentioned above, the combination of SF and sTfR levels can portray the spectrum of iron deficiency from normal to severe. This can be demonstrated by plotting body iron status against the logarithm of the sTfR to SF ratio, resulting in a linear relationship. The sTfR measures the deficit in tissue iron once ferritin levels drop below 12 µg/l.

Unlike SF, sTfR remains normal in patients with acute or chronic inflammation or liver disease and appears to be effective in distinguishing iron deficiency anemia from anemia as a result of chronic disease.[40] The normal range for sTfR is 3-9 µg/ml. Levels of three to four times normal have been reported for iron deficiency anemia.[41][42] There is currently no universally agreed normal range for sTfR. An increase in sTfR is a response during early development of iron deficiency. Levels of sTfR increase progressively as the supply of iron to the tissues becomes progressively more deficient.

Major advantages of sTfR are that it is not an acute phase reactant and does not vary with age, gender, or pregnancy. However, sTfR levels may be elevated when there is increased red blood cell production, turnover, or both, such as in the case of hemolytic anemia.

A2.2.2.iii Combination of Serum Ferritin and Serum Transferrin Receptor

The combination of SF and sTfR in populations provides the most complete picture of iron status. Because serum ferritin levels increase in the presence of inflammation and sTfR, in general, is not affected by inflammation, the combination of the tests is optimal and the interpretation of the tests is provided in Table A2.6. Note that the classification proposed in Table A2.6 requires further validation.

Table A2.6 The interpretation of low serum ferritin and high transferrin receptor concentrations in population surveys: this classification is based on experience of measuring ferritin and transferrin receptor in research studies and requires validation in population surveys.

Percentage of serum ferritin values below threshold[a]	Percentage of transferrin receptor values above threshold[b]	Interpretation
<20%[c]	<10%	Iron deficiency is not prevalent
<20%[c]	≥10%	Iron deficiency is prevalent; Inflammation is prevalent
≥20%[d]	≥10%	Iron deficiency is prevalent
≥20%[d]	<10%	Iron depletion is prevalent

Source: WHO/CDC 2005 (WD 105)
[a] Apply thresholds by age group for serum ferritin given in Table A2.5
[b] Apply thresholds recommended by manufacturer of assay until an international reference standard is available
[c] <30% for pregnant women
[d] ≥30% for pregnant women

A2.2.3   Iron Deficiency Anemia - Control program indicators

Some national programs may have a mix of interventions to address iron deficiency, such as iron supplementation of high prevalent groups, food fortification, and dietary approaches.

A2.2.3i Iron Supplementation Coverage

In many countries the main intervention for controlling anemia is the routine use of iron supplements during pregnancy. Although other strategies may be part of national programs, one of the imprortant indicators is to estimate the proportion of pregnant women who are receiving and/or taking iron supplements. In some circumstances it may be useful to identify factors of non-compliance and determine the characteristics of women are taking supplements compared to those who do not. An important constraint to the effective implementation of iron supplementation has been a lack of awareness and compliance among targeted women, and the survey could provide an opportunity to understand some of these factors. Use of qualitative methods, such as in-depth interviews or focus groups prior to the survey would assist in the development of relevant questions and responses. As with any of the program indicators based on recall, it is important to standardize the questions and field test them before

implementation. In order to 'validate' recall of iron supplement compliance, it is possible to use quantitative measures, such as the iron content in stools, but this is more often applied in research settings rather than in large population-based surveys.

In countries with a high prevalence of anemia in children, there may be programs to provide iron supplments to this group. As with women, the coverage of iron supplementation in children could be assessed.

A2.2.3ii Iron Fortification of Food

A number of food items can be fortified with iron, such as flour and complementary foods. Countries with fortification programs will most likely want to assess the proportion of households using fortified products. For some fortified foods it may to be useful to obain a small sample of the food for laboratory analysis. If possible, the brand name, manufacturer, and whether the package is labelled as fortified should be collected.

A2.2.3iii Dietary-Related Factors

Certain foods contain substances that enhance or inhibit dietary iron absorption. Tea and coffee consumption during a meal can inhibit iron absorption. Red meats have highly absorbable iron and enhance the absorption of iron from other foods.[8] Vitamin C enhances iron absorption. Some countries may have public health interventions concerning dietary approaches to improve iron status and therefore may want to assess the knowledge, attitudes, and practices concerning these messages and people's experiences with and preceptions of the intervention. In newborns, exclusive breastfeeding is an effective way to improve iron deficiency in infants less than 6 months of age.[8] As a general rule we would not recommend a comprehensive dietary assessment to estimate iron intake. However, for countries that feel a dietary assessment wold be useful, the International Life Science Institute (ILSI) has a tool for the assessment of iron intake, "An Interactive 24-hour Recall for Assessing the Adequacy of Iron and Zinc Intakes in Developing Countries" (http://www.ilsi.org/file/Recall.pdf).

A2.3 Iodine Deficiency

The primary indicator of iodine deficiency is urinary iodine concentration (UI) and the primary measure of coverage in most areas is the proportion of households using adequately iodized salt (Table A2.7). Details of these and other possible indicators and sustainable elimination criteria can be found elsewhere.[43] Some additional details of urinary iodine and salt iodine levels are described next.

Table A2.7 Summary of criteria for monitoring progress towards sustainable elimination of IDD

Indicators		Goals
Salt iodization -	Proportion of households using adequately iodized salt*	> 90%
Urinary iodine -	Proportion of school-age children with a UI below 100 μg/l	< 50%
-	Proportion of school-age children with a UI below 50 μg/l	< 20%

*Internationally defined as ≥15 ppm
Source: WHO/NHD/01.1, 2001

Although there are other clinical and biological indicators of iodine status, including goiter and thyroid volume by ultrasonography, these are not recommended for cross-sectional surveys. Measures of thyroid size are slow to respond to changes in iodine status, such as occurs when a salt iodization program has been recently implemented, and could provide misleading information on the *current* status of iodine deficiency in a population.[44]

A2.3.1 Urinary iodine as the primary indicator of iodine nutrition

For iodine deficiency, there are two goals: fewer than 50% of school-age children with urine specimens having an iodine concentration less than 100 μg/l *and* fewer than 20% of school-age children with urine specimens having an iodine concentration less than 50 μg/l (Table A2.7). Some important features of UI include:

- Most survey participants are willing to provide urine specimens
- Only a small amount of urine is required (0.5-1.0 ml) for laboratory testing
- UI is a good marker of recent dietary iodine intake of the *population*
- In individuals, UI varies throughout the day and from day to day, therefore a single UI is *not* a useful indicator of iodine status at the *individual level*
- Relating iodine to creatinine is unnecessary (per WHO recommendations)[43]
- Transportation of urine specimens does not require refrigeration or preservation

Details on urinary specimen storage and iodine laboratory methods can be found elsewhere.[43] Urinary iodine assays are relatively simple to perform but require special attention to prevent iodine contamination of the laboratory area and equipment.

Additional interpretation of urinary iodine based on median levels *in school-aged children* is presented in Table A2.8. For school-aged children, an "adequate" iodine intake is defined as a median urinary iodine in the 100-299 μg/l range. The WHO/UNICEF/ICCIDD document on IDD mentions in several places that "adult women" can be assessed, however, appropriate urinary iodine cutoffs were not

provided. One author has recommended that an adequate iodine intake in adult women is the same as for school-aged children, and for pregnant and lactating women the recommended median UI is in the 150-230 μg/l range.[45] A more recent WHO consultation recommends a median UI in pregnant women to be ≥150 μg/l.(unpublished report)

Table A2.8 provides interpretation of median UI levels in school-age children. Populations with "insufficient intake" of iodine may be defined as having *severe*, *moderate*, or *mild* iodine deficiency. A common misinterpretation of Table A2.8 is to state that **individuals** with a urinary iodine <20 μg/l have "severe" iodine deficiency, **individuals** with a urinary iodine 20-49 μg/l have "moderate" iodine deficiency, and **individuals** with a urinary iodine 20-49 μg/l have "mild" iodine deficiency. As stated earlier, casual urine specimens are **not** useful for classifying *individuals*, but summary information (proportion below a cutoff or a median) is useful for classifying *populations*.

Table A2.8 Epidemiologic criteria for assessing iodine nutrition based on median urinary iodine concentrations in school-aged children

Median urinary iodine (μg/l)	Iodine intake	Iodine nutrition
< 20	Insufficient	Severe iodine deficiency
20-49	Insufficient	Moderate iodine deficiency
50-99	Insufficient	Mild iodine deficiency
100-199	Adequate	Optimal
200-299	More than adequate iodine intake	Risk of iodine-induced hyperthyroidism within 5 or 10 years following introduction of iodised salt in susceptible groups
>300	Excessive iodine intake	Risk of adverse health consequences (Iodine-induced hyperthyroidism, autoimmune thyroid disease)

Source: WHO/NHD/01.1, 2001

A2.3.2 Salt iodine level

The goal is to have 90% of households using adequately iodized salt (Table A2.7), defined internationally as ≥15 ppm. The primary indicator for iodized salt intervention programs is the proportion of households with iodized salt.

The reference standard for testing iodine in salt is by iodometric titration. A complete iodometric titration kit can be purchased from UNICEF for approximately US$ 1,000; materials from United States companies can cost US$2,000 to $3,000. Reagents to process 1,000 salt samples cost approximately US$330. In testing the level of potassium iodate (KIO_3) or potassium iodide (KI) in salt, a salt sample is

dissolved in water, sulfuric acid, and KI. This solution is then titrated with sodium thiosulfate in the presence of a starch indicator until the solution is colorless. The volume of sodium thiosulfate used to turn the salt solution colorless is then converted to determine the iodine concentration (parts per million) in the original salt sample. The procedures for measuring KIO_3 and KI differ slightly.

Another method for measuring iodine in salt is the WYD Iodine Checker (Salt Research Institute, China National Salt Industry Corporation). This is a compact filter photometer, was tested independently by the China National IDD Reference Laboratory, the University of Toronto, and CDC and shown to be accurate, precise, stable, and easy to use and transport. The WYD Checker uses the same chemical reaction system as iodometric titration, but removes the titration step and replaces it with a measurement by a single-wavelength photometer.

At the household frequently a semi-quantitative rapid test kit is used to determine the level of iodine in salt. There are many simple test kits available that use the principle of reducing iodate to elemental iodine with excess KIO_3 in the presence of dilute acid. The liberated iodine is then reacted with starch beta-amylase to form a blue complex. Unfortunately, while these test kits provide an immediate result, their sensitivity and specificity can be low. Most field test kits include a bottle of starch solution and a color chart for qualitatively determining the level of iodine. The starch solution is dropped on a sample of salt and the color intensity of the spot indicates the iodine content. UNICEF distributes field test kits produced by Erirez MBI (Bangalore, India). Each ampule of starch solution can be used to test as many as 100 salt samples and a box of three ampoules costs approximately US$0.50.

We recommend that either the titration method or the WYD Iodine Checker be used in every survey assessing the iodine content of salt. Either all salt collected in households could be tested or a sub-sample of salt tested.

A2.3.3 Other Iodine Program-Related Information

If possible, when salt is tested, the brand name, manufacturer of the salt, and whether the package is labelled as iodized should be collected. In some countries, information concerning the type of salt used, such as whether it is refined or large crystal, packaged or sold in bulk, might be useful. Some countries may also ask questions concerning knowledge of iodine deficiencies and iodized salt as well as attitudes and practices concerning the use of iodized salt.

A2.4 Acute Phase Reactant

Infection and trauma are accompanied by an acute phase response, a collection of non-specific changes which includes the production of proteins to promote inflammation, activate complement, and stimulate phagocytic cells.   The main purpose is to prevent further damage to tissues and remove harmful molecules and pathogens.   During the acute phase response the concentration of some acute phase proteins (APPs), called *positive APPs*, increase in the plasma, e.g., C-reactive protein (CRP), α-1 acid glycoprotein (AGP) and ferritin.   Other APPs decrease and are called *negative APPs*, e.g., retinol binding protein (RBP), albumin, and transferrin.   In many developing countries the prevalence of infection is high and many individuals will have a low level acute phase response, even some may show no evidence of clinical disease. An acute phase response will result in a change in many indicators of micronutrient status, e.g., serum retinol, ferritin, hemoglobin, leading to an over- or under-estimation of deficiency.

Vitamin A and infection interact whereby both exacerbate and increase the vulnerability to the other. Infection can induce vitamin A deficiency in a variety of ways depending on the cause, duration, and severity of infection. Vitamin A status is estimated by measuring plasma or serum retinol, but because serum retinol is lowered by clinical and sub-clinical infection, the serum retinol measurements may overestimate the prevalence of vitamin A deficiency in a population with a high prevalence of infection. To deal with the problem of potentially overestimating the prevalence of vitamin A deficiency, it would be useful to measure one or more APPs in the survey.

A meta-analysis by Thurnham et al.,[46] suggested two approaches for correcting serum retinol for the presence of sub-clinical infection: the first is to use the serum retinol concentrations of only those individuals classed as "healthy", i.e., without an elevated APP.   The second approach is to use a correction factor for serum retinol based on the number of individuals with elevated APPs, with the authors providing correction factors.

Calculating the prevalence of low retinol concentrations in the "healthy" group of a population to estimate the prevalence of vitamin A deficiency is straightforward, but might result in small sample sizes, especially in areas where there is a high prevalence of infection such as malaria.   There is also concern that healthy individuals may not be truly representative of the population which could bias the prevalence of VAD downward.

While infection affects some of the other indicators of micronutrient status, there has been no meta-analysis to establish whether a correction can be done.

Appendix 3
Modified UNICEF Multiple Indicator Cluster Survey (MICS) Questionnaires

In this appendix is a modified form of the UNICEF MICS questionnaires that relate to micronutrients (and factors that may affect micronutrient status) and anthropometry and is presented here as an example. In general, there is a household questionnaire in which the household salt is tested for iodine. This is followed by a questionnaire for a woman that collects information on vitamin A capsules after birth. Next, information on children is collected. This has information on each child, their breastfeeding status, whether the child has or has recently had a diarrheal or upper respiratory illness and treatment provided for the illness, questions related to malaria, and then anthropometry. For more information on the UNICEF MICS please visit www.childinfo.org.

HOUSEHOLD QUESTIONNAIRE

WE ARE FROM (**country-specific affiliation**). WE ARE WORKING ON A PROJECT CONCERNED WITH FAMILY NUTRITION. I WOULD LIKE TO TALK TO YOU ABOUT THIS. THE INTERVIEW WILL TAKE ABOUT (**number**) MINUTES. ALL THE INFORMATION WE OBTAIN WILL REMAIN STRICTLY CONFIDENTIAL AND YOUR ANSWERS WILL NEVER BE IDENTIFIED. DURING THIS TIME I WOULD LIKE TO SPEAK WITH THE HOUSEHOLD HEAD AND ALL MOTHERS OR OTHERS WHO TAKE CARE OF CHILDREN IN THE HOUSEHOLD.

MAY I START NOW? *If permission is given, begin the interview.*

HOUSEHOLD INFORMATION PANEL	HH

HH1. Cluster number:

___ ___ ___

HH2. Household number:

___ ___ ___

HH3. Interviewer name and number:

Name_____ ___ ___

HH4. Supervisor name and number:

Name_____ ___ ___

HH5. Day/Month/Year of interview:

___ ___ / ___ ___ / ___ ___ ___ ___

HH6. Area:
Urban..1
Rural...2

HH7. Region:
Region 1 1
Region 2 2
Region 3 3
Region 4 4

HH 8. Name of head of household:

_____

After all questionnaires for the household have been completed, fill in the following information:

HH9. Result of HH interview:

Completed 1
Not at home.............................2
Refused 3
HH not found/destroyed 4

Other (*specify*) 6

HH10. Respondent to HH questionnaire:

Name:_____

Line No: ___ ___

HH11. Total number of household members:

___ ___

HH12. No. of women eligible for interview:

___ ___

HH13. No. of eligible women questionnaires completed:

___ ___

HH14. No. of children under age 5:

___ ___

HH15. No. of under-5 questionnaires completed:

___ ___

INTERVIEWER/SUPERVISOR NOTES: *Use this space to record notes about the interview with this household, such as call-back times, incomplete individual interview forms, number of attempts to re-visit, etc.*

HH16. Data entry clerk: ____ ____

Cluster number: __ __ __   Household number: __ __ __

Household Listing Form					
FIRST, PLEASE TELL ME THE NAME OF EACH PERSON WHO USUALLY LIVES HERE, STARTING WITH THE HEAD OF THE HOUSEHOLD. *List the head of the household in line 01. List all household members names (HL2), and their sex (HL4).* *Then ask*: ARE THERE ANY OTHERS WHO LIVE HERE, EVEN IF THEY ARE NOT AT HOME NOW? *(*THESE MAY INCLUDE CHILDREN IN SCHOOL OR AT WORK*). If yes, complete listing.* *Add a continuation sheet if there are more than 20 household members. Tick here if continuation sheet used ☐*					
				Eligible for:	
				Women's Module	Child's Module
HL1. Line No.	HL2. Name	HL3. Sex 1=Male 2=Female M F	HL4. How old is (name) in years?	HL5. Circle if Female *AND* 15-49 years (up to 50th birthday)	HL6. Circle if <5 years old
01		1 2		01	01
02		1 2		02	02
03		1 2		03	03
04		1 2		04	04
05		1 2		05	05
06		1 2		06	06
07		1 2		07	07
08		1 2		08	08
09		1 2		09	09
10		1 2		10	10
11		1 2		11	11
12		1 2		12	12
13		1 2		13	13
14		1 2		14	14
15		1 2		15	15
16		1 2		16	16
17		1 2		17	17
18		1 2		18	18
19		1 2		19	19
20		1 2		20	20
Totals				__ __	__ __

Cluster number __ __ __   Household number __ __ __

I WOULD LIKE TO TALK TO THE PERSON WHO DOES MOST OF THE COOKING FOR THE HOUSEHOLD.

Ask the following questions to the person who prepares most meals for the household.

SALT IODIZATION MODULE		SI
SI1. WE WOULD LIKE TO CHECK WHETHER THE SALT USED IN YOUR HOUSEHOLD IS IODIZED. MAY I SEE A SAMPLE OF THE SALT USED TO COOK THE MAIN MEAL EATEN BY MEMBERS OF YOUR HOUSEHOLD LAST NIGHT? *Once you have examined the salt, circle number that corresponds to test outcome.*	Not iodized 0 PPM ....1 Less than 15 PPM ....2 15 PPM or more ....3 No salt in home...6 Salt not tested...7	
Also, ask permission to take a small sample of salt for later analysis. If permission given, collect and label salt specimen. SI2. *Was a salt sample collected?*	Yes...1 No 2	
SI3. MAY WE SEE THE ORIGINAL PACKAGE FOR THE SALT? *Provide the most appropriate response.*	Package not available ....1 Package available - labeled iodized............2 Package available - **NOT** labeled as iodized*3*	1 ⇨ FF1
SI4. *Please write the brand name of the salt*	_____	
FOOD FORTIFICATION **		FF
FF1. WE WOULD LIKE TO KNOW IF SOME FOOD PRODUCTS ARE USED IN YOUR HOUSEHOLD. DO YOU HAVE [FORTIFIED FOOD PRODUCT] IN THE HOUSE? **REPEAT FOR EACH FORTIFIED FOOD**	Yes.. 1 No .... 2 DK.. 8	

*Note to individual developing questionnaire and data entry; there are different salt kits, the most common kit providing potassium *iodate* in ppm as 0, 7, 15, and 30. There are kits available with different ppm values and kits for potassium *iodide*. Some countries may want to take a sample of salt for iodine titration testing, requiring a question concerning whether a sample of salt was obtained from this household.

**This is a general food fortification questions that would need to be modified for each country. For example, some countries fortify flour with iron and folate and may ask flour-related questions; others that fortify sugar with vitamin A and may want to ask sugar-related questions. Similar to salt, it may be useful to collect information on the brand name and whether the packaging is labeled as fortified.

QUESTIONNAIRE FOR INDIVIDUAL WOMEN

WOMEN'S INFORMATION PANEL	WM
This module is to be administered to all women age 15 through 49 years (see column HL5 of HH listing). *Fill in one form for each eligible woman* *Fill in the cluster and household number, and the name and line number of the woman in the space below. Fill in your name, number and the date.*	

WM1. Cluster number: ___ ___ ___	WM2. Household number: ___ ___ ___
WM3. Woman's Name:	WM4. Woman's Line Number: ___ ___
WM5.Interviewer name and number:	WM6. Day/Month/Year of interview: ___ ___ / ___ ___ / ___ ___ ___ ___
WM7. Result of women's interview	Completed .... 1 Not at home .... 2 Refused .... 3 Partly completed .... 4 Incapacitated .... 5 Other (*specify*) _____ 6

Repeat greeting if not already read to this woman:

WE ARE FROM (country-specific affiliation). WE ARE WORKING ON A PROJECT CONCERNED WITH FAMILY NUTRITION. I WOULD LIKE TO TALK TO YOU ABOUT THIS. THE INTERVIEW WILL TAKE ABOUT (number) MINUTES. ALL THE INFORMATION WE OBTAIN WILL REMAIN STRICTLY CONFIDENTIAL AND YOUR ANSWERS WILL NEVER BE IDENTIFIED. ALSO, YOU ARE NOT OBLIGED TO ANSWER ANY QUESTION YOU DON'T WANT TO, AND YOU MAY WITHDRAW FROM THE INTERVIEW AT ANY TIME. MAY I START NOW?

If permission is given, begin the interview. If the woman does not agree to continue, thank her, complete WM7, and go to the next interview. Discuss this result with your supervisor for a future revisit.

WM8. IN WHAT MONTH AND YEAR WERE YOU BORN?	WM6. DOB of woman: Day/Month/Year ___ ___ / ___ ___ / ___ ___ ___ ___	
WM9. HOW OLD WERE YOU AT YOUR LAST BIRTHDAY?	Age (in completed years) .... ___ ___	
WM10. ARE YOU CURRENTLY PREGNANT?	Yes .... 1 No .... 2 DK/Not sure 8	
WM11. ARE YOU CURRENTLY MARRIED OR LIVING TOGETHER WITH A MAN AS IF MARRIED?	Yes, currently married .... 1 Yes, living with a man .... 2 No, not in union 3	

WM12. HAVE YOU EVER ATTENDED SCHOOL?	Yes .... 1 No.. 2	2⇨WM16
WM13. WHAT IS THE HIGHEST LEVEL OF SCHOOL YOU ATTENDED: PRIMARY, SECONDARY, OR HIGHER?	Primary.. 1 Secondary .... 2 Higher... 3 Non-standard curriculum............................ 6	
WM14. WHAT IS THE HIGHEST GRADE YOU COMPLETED AT THAT LEVEL?	Grade .... __ __	
WM15. *Check WM13:* ☐ *Secondary or higher.* ⇨ *Go to Next Module* ☐ *Primary or non-standard curriculum.* ⇨ *Continue with WM16*		

WM16. NOW I WOULD LIKE YOU TO READ THIS SENTENCE TO ME.
 	
Show sentences to respondent.
If respondent cannot read whole sentence, probe:
CAN YOU READ PART OF THE SENTENCE TO ME?
 	
Example sentences for literacy test:
 	
1. *The child is reading a book.*
2. *The rains came late this year.*
3. *Parents must care for their children.*
4. *Farming is hard work.*
	Cannot read at all....................................... 1
	Able to read only parts of sentence 2
	Able to read whole sentence 3
	No sentence in
	   required language_____ 4
	
	                              (specify language)
	Blind/mute, visually/speech impaired.......... 5	

MATERNAL AND NEWBORN HEALTH MODULE		MN
This module is to be administered to all women with a live birth in the 2 years preceding date of interview. *Record name of last-born child here _____.* *Use this child's name in the following questions, where indicated.*		
MN1. NOW I WOULD LIKE TO ASK ABOUT ALL THE BIRTHS YOU HAVE HAD DURING YOUR LIFE. HAVE YOU EVER GIVEN BIRTH? *If "No" probe by asking:* I MEAN, TO A CHILD WHO EVER BREATHED OR CRIED OR SHOWED OTHER SIGNS OF LIFE – EVEN IF HE OR SHE LIVED ONLY A FEW MINUTES OR HOURS?	Yes .... 1 No.. 2	2⇨next module
MN2. OF THESE (*total number*) BIRTHS YOU HAVE HAD, WHEN DID YOU DELIVER THE LAST ONE (EVEN IF HE OR SHE HAS DIED)? If day is not known, enter '98' in space for day.	Date of last birth Day/Month/Year ..... __ __/__ __/__ __ __ __	

MN3. *Check MN2: Did the woman's last birth occur within the last 2 years?*		
If child has died, take special care when referring to this child by name in the following modules.		
☐ *No live birth in last 2 years.* ⇨ *Go to CARE OF ILLNESS.*		
☐ *Yes, live birth in last 2 years.* ⇨ *Continue with MN4*		
Name of child_____		
MN4. IN THE FIRST TWO MONTHS AFTER YOUR LAST BIRTH [THE BIRTH OF *name*], DID YOU RECEIVE A VITAMIN A DOSE LIKE THIS? *Show 200,000 IU capsule or dispenser.*	Yes .... 1 No... 2 DK 8	
MN5. DURING YOUR LAST PREGNANCY, DID YOU USE IRON TABLETS LIKE THIS? *Show iron tablet.*	Yes .... 1 No... 2 DK 8	2 ⇨ MN8 9 ⇨ MN8
MN6. IF YES, FROM WHOM DID YOU RECEIVE THE TABLETS?	Neighbor... 1 Health clinic... 2 Pharmacy .... 3 Other _____ .... 4 DK 8	
MN7. ON AVERAGE, HOW OFTEN DID YOU TAKE USE THE IRON TABLETS DURING YOUR LAST PREGNANCY?	Every day .... 1 Between 1 to 6 times per week................... 2 Once per week .... 3 Less than once per week............................ 4 DK 8	
MN8. DID YOU EVER BREASTFEED (NAME)?	Yes .... 1 No... 2	2⇨ next module
MN9. HOW LONG AFTER BIRTH DID YOU FIRST PUT (NAME) TO THE BREAST? *If less than 1 hour, record '00' hours.* *If less than 24 hours, record hours.* *Otherwise, record days.*	Immediately... 000 Hours... 1 __ __ or Days .... 2 __ __ Don't know/remember............................. 998	

CARE OF ILLNESS MODULE		CA
CA1. HAVE YOU HAD DIARRHOEA IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST? *Diarrhoea is determined as perceived by the respondent, or as three or more loose or watery stools per day, or blood in stool.*	Yes .... 1 No... 2 DK 8	
CA2. HAVE YOU HAD AN ILLNESS WITH A COUGH AT ANY TIME IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST?	Yes .... 1 No... 2 DK 8	

| CA3. HAVE YOU HAD AN ILLNESS WITH A FEVER AT ANY TIME IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST? | Yes 1
 No 2

 DK .... 8 | |

TEA/COFFEE CONSUMPTION		**TC**
TC1. DO YOU DRINK TEA OR COFFEE?	Yes .... 1 No .... 2 DK 8	2 ⇨ next module 8 ⇨ next module
TC2. HOW OFTEN DO YOU DRINK TEA OR COFFEE?	Usually every day .... 1 Usually 1 to 6 times per week .... 2 Usually around once per week .... 3 Less than once per week .... 4 DK 8	
TC3. WHEN YOU DRINK TEA OR COFFEE, DO YOU USUALLY DRINK IT DURING A MEAL?	Yes .... 1 No .... 2 DK 8	

SPECIMEN COLLECTION		
SC1. Was a urine sample collected from the woman?	Yes .... 1 No .... 2 DK 8	
SC2. Was a finger stick blood sample collected from the woman?	Yes .... 1 No .... 2 DK 8	
SC3. Hemoglobin level from HemoCue	Hemoglobin __ __ . __	

QUESTIONNAIRE FOR CHILDREN UNDER FIVE

UNDER-FIVE CHILD INFORMATION PANEL	UF
This questionnaire is to be administered to all mothers or caretakers who care for a child that lives with them and is under the age of 5 years. *A separate questionnaire should be used for each eligible child.* *Fill in the cluster and household number, and names and line numbers of the child and the mother/caretaker in the space below. Insert your own name and number, and the date.*	

UF1. Cluster number: ___ ___ ___	UF2. Household number: ___ ___ ___
UF3. Child's Name: _	UF4. Child's Line Number: ___ ___
UF5. Mother's/Caretaker's Name: _	UF6. Mother's/Caretaker's Line Number: ___ ___
UF7. Interviewer name and number: _	UF8. Day/Month/Year of interview: ___ ___ / ___ ___ / ___ ___ ___ ___
UF9. Result of interview for children under 5 (Codes refer to mother/caretaker.)	Completed... 1 Not at home .... 2 Refused.. 3 Partly completed .... 4 Incapacitated... 5 Other (specify) _____ 6

Repeat greeting if not already read to this respondent:
WE ARE FROM (country-specific affiliation). WE ARE WORKING ON A PROJECT CONCERNED WITH FAMILY HEALTH
   AND EDUCATION. I WOULD LIKE TO TALK TO YOU ABOUT THIS. THE INTERVIEW WILL TAKE ABOUT (number)
   MINUTES. ALL THE INFORMATION WE OBTAIN WILL REMAIN STRICTLY CONFIDENTIAL AND YOUR ANSWERS WILL
   NEVER BE IDENTIFIED. ALSO, YOU ARE NOT OBLIGED TO ANSWER ANY QUESTION YOU DON'T WANT TO, AND YOU
   MAY WITHDRAW FROM THE INTERVIEW AT ANY TIME. MAY I START NOW?

If permission is given, begin the interview. If the respondent does not agree to continue, thank him/her and go to the next interview. Discuss this result with your supervisor for a future revisit.

UF10. Now I would like to ask you some questions about the health of each child under the age of 5 in your care, who lives with you now. Now I want to ask you about (*name*). In what month and year was (*name*) born? *Probe:* What is his/her birthday? *If the mother/caretaker knows the exact birth date, also enter the day; otherwise, circle 98 for day.*	UF10. DOB of child: Day/Month/Year ___ ___ / ___ ___ / ___ ___ ___ ___	
UF11. How old is (*name*) in months? *Record age in completed months.*	Age in completed months .... __ __	

VITAMIN A MODULE		**VA**
VA1. Has (*name*) ever received a vitamin A capsule (supplement) like this one? *Show capsule or dispenser for different doses – 100,000 IU for those 6-11 months old, 200,000 IU for those 12-59 months old.*	Yes .... 1 No.. 2 DK 8	2⇨next module 8⇨next module
VA2. How many months ago did (*name*) take the last dose?	Months ago .... __ __ DK 98	
VA3. Where did (*name*) get this last dose?	On routine visit to health facility .... 1 Sick child visit to health facility .... 2 National Immunization Day campaign .... 3 Other (*specify*) _____ 6 DK 8	

BREASTFEEDING MODULE		**BF**
BF1. Has (*name*) ever been breastfed?	Yes .... 1 No.. 2 DK 8	2⇨TC1 8⇨TC1
BF2. Is he/she still being breastfed?	Yes .... 1 No.. 2 DK 8	

TEA/COFFEE CONSUMPTION		**TC**
TC1. Does (*name*) drink tea or coffee?	Yes .... 1 No.. 2 DK 8	2 ⇨ CA1 8 ⇨ CA1
TC2. How often does (*name*) drink tea or coffee?	Usually every day.. 1 Usually 2 to 3 times per week..................... 2 Usually around once per week .... 3 Less than once per week............................ 4 DK 8	

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TC3. WHEN (NAME) DRINKS TEA OR COFFEE, DOES HE/SHE USUALLY DRINK IT DURING A MEAL?	Yes .... 1 No... 2 DK 8	

CARE OF ILLNESS MODULE		**CA**
CA1. HAS (*name*) HAD DIARRHOEA IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST? *Diarrhoea is determined as perceived by mother or caretaker, or as three or more loose or watery stools per day, or blood in stool.*	Yes .... 1 No... 2 DK 8	
CA2. HAS (*name*) HAD AN ILLNESS WITH A COUGH AT ANY TIME IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST?	Yes .... 1 No... 2 DK 8	
CA3. HAS (*name*) HAD AN ILLNESS WITH A FEVER AT ANY TIME IN THE LAST TWO WEEKS, THAT IS, SINCE (*day of the week*) OF THE WEEK BEFORE LAST?	Yes .... 1 No... 2 DK 8	

ANTHROPOMETRY MODULE		**AN**
After questionnaires for all children are complete, the measurer weighs and measures each child. Record weight and length/height below, taking care to record the measurements on the correct questionnaire for each child. Check the child's name and line number on the household listing before recording measurements.		
AN1. Child's weight.	Kilograms (kg) .... __ __ . __	
AN2. Child's length or height. Check age of child in UF11: ☐ Child under 2 years old. ⇨ Measure length (lying down). ☐ Child age 2 or more years. ⇨ Measure height (standing up).	Length (cm) Lying down .... 1 __ __ __ . __ Height (cm) Standing up .... 2 __ __ __ . __	
AN3. Measurer's identification code.	Measurer code .... __ __	
AN4. Result of measurement.	Measured .... 1 Not present .... 2 Refused.. 3 Other (*specify*) _____ 6	

SPECIMEN COLLECTION		**SC**
SC1. *Was a finger stick blood sample collected from this child?*	Yes .... 1 No .... 2 DK 8	
SC2. *Hemoglobin level from HemoCue*	Hemoglobin __ __ . __	

Appendix 4
Basic Issues in Sampling

A4.1 General sampling issues and terminology

One of the primary goals of a cross-sectional survey is to collect information on a sample population representative of the target population. The *representativeness* is extremely important for a number of reasons. First, the results may be used for improving or targeting interventions; second, the survey results may be compared with previous estimates to determine trends and used for comparisons with future surveys. When those surveyed are representative of the target population, the estimates from the sample are said to be "valid". If the group sampled differs systematically from the target population on characteristics related to the outcome, then the estimates from the sample may be "biased".

Precision around an estimate is another issue, which can be presented by use of confidence intervals. Because a survey provides only an estimate, the confidence limits provide a range of values that most likely capture the "true" target population proportion (assuming the sample is representative of the target population). As a general rule, the larger the sample size, the better the precision (i.e., the narrower the confidence interval).

Cross-sectional surveys provide estimates of the proportion (or percentage) of individuals or households with a characteristic. The survey is cross-sectional in that it provides estimates at a point in time, i.e., a "snapshot" of the health status of a population. When the characteristic is whether or not individuals have a condition of interest, this proportion is frequently referred to as "prevalence". For example, a cross-sectional survey might estimate the prevalence of VAD or anemia. "Prevalence" is different from "risk"; prevalence is the proportion of individuals with a condition at a point in time whereas *risk* is the probability of initially disease-free individuals developing the disease over a specified time period. Another term for risk is *incidence*.

When the characteristic in a cross-sectional survey being measured is the proportion (or percentage) with an intervention, this is frequently referred to as "coverage". For example, the proportion of children who received a vitamin A supplement within the previous 6 months is frequently referred to as "vitamin A supplement coverage".

A4.2 Example of Simple and Systematic Sampling

Before presenting the complexities associated with performing surveys on a national or sub-national level, some of the concepts of sampling will be described for simpler situations. In situations where a list of eligible individuals is available, to select a representative sample from this list, two common sampling methods are simple random sampling (SRS) and systematic sampling. As a simple illustrative example, Table A4.1 presents data from a clinic that has 50 non-pregnant women enrolled and their "true" anemia status is presented. Of course in a field setting we would not know the anemia status of the population prior to selection, but for illustrative purposes their status is shown. In this group of 50 women, 26 are anemic for a prevalence of 52%. Say we want to sample ten women and determine their anemia status. One way to select ten women would be to use a random number table (Appendix 6) or computer program to identify 10 numbers between 1 and 50. For example, say the following 10 numbers were randomly selected: 1, 16, 17, 18, 28, 38, 40, 42, 43, and 50. Of the 10 women with these numbers, five women would be found to be anemic for a prevalence of 50%. With a different random selection of 10 the results could be different; for example, randomly selecting women number 11, 18, 20, 21, 24, 30, 34, 41, 42, and 49 would identify 6 out of 10 as anemic for a prevalence of 60%. It is possible that 10 numbers could be randomly selected where none of the women were anemic or where all of the women were anemic. These probabilities are shown in Figure A4.1.

Table A4.1 Illustrative example of 50 non-pregnant women of childbearing age with anemia status

No.	Anemic	No.	Anemic	No.	Anemic	No.	Anemic	No.	Anemic
1	Y	11	Y	21	N	31	N	41	Y
2	Y	12	N	22	N	32	Y	42	N
3	N	13	Y	23	Y	33	N	43	N
4	N	14	N	24	Y	34	N	44	Y
5	N	15	N	25	Y	35	Y	45	N
6	Y	16	Y	26	Y	36	Y	46	N
7	Y	17	N	27	Y	37	N	47	N
8	N	18	Y	28	Y	38	N	48	N
9	N	19	Y	29	N	39	Y	49	Y
10	Y	20	N	30	Y	40	Y	50	Y

In Figure A4.1 the probabilities of selecting between 0 and 10 anemic women out of 10 randomly selected women from this clinic population is presented. While conceptual, the idea is that if you were to

randomly select 10 women from this clinic population thousands of times, what would be the distribution of the number of anemic women identified from all the thousands of samples? This is conceptual because in practice we would only take one sample, however it is important to understand that different samples could result in different estimates. The probability of randomly selecting zero anemic women is low (only .06%); the probability of randomly selecting 10 anemic women is also low (0.1%), but either is possible, just very unlikely. The most likely number of anemic women out of 10 would be 5 anemic women, which would occur in 24.4% of the samples. That is, if you were to sample 10 women from the clinic population 1000 times, in 244 samples you would find exactly 5 anemic women; the other 756 samples you would identify fewer or more anemic women.

Figure A4.1 Probability of randomly selecting anemic women; assumes there are 50 women from which 10 are randomly selected with a "true" proportion of 52%
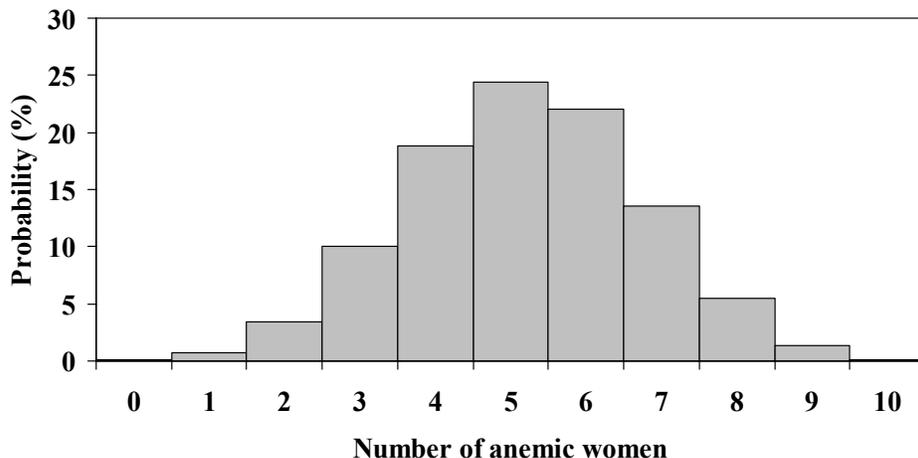
The above provides an example of randomly selecting individuals from a list. It also illustrates the concept that a prevalence estimate from a sample is only an *estimate*; it is hoped that this estimate will be close to the "true" target population value.

Systematic sampling is another way that could be used to select women from Table A4.1. With systematic sampling, divide the total number in the target population (in our example, 50) by the number to be sampled (in our example 10) to determine a *sampling interval* (50/10=5). The sampling interval of 5 indicates that we would select every fifth woman from Table A4.1 to be in the survey. However, we need to have a "random start", that is, pick a random number using a random number table or program from 1 to 5 to determine where to start the systematic selection. For example, say the number 2 was selected, this would result in the following women being selected: 2, 7, 12, 17, 22, 27, 32, 37, 42, and 47.

From these selected women, 4 out of 10 would be found to be anemic for a prevalence of 40%. The prevalence that would be found for each of the random starting numbers from 1 to 5 and then systematically selecting every fifth woman is shown below:

1   70%

2   40%

3   40%

4   50%

5   60%

Some might express concern over how far some of the sample estimates are from the target value, noting that sample estimates of 40% and 70% are quite distant from "true" target prevalence of 52%. This is an issue of precision and as sample size increases, each sample estimate will, on average, be closer to the target value. For example, with systematic selection of 25 women and a random start of 1 the prevalence would be 48% (12/25); with a random start of 2 the prevalence would be 56% (14/25). Sample size is covered in more detail elsewhere in this document. From a statistical viewpoint simple random sampling is preferred; however, from a practical viewpoint, in some situations it might be easier to use systematic selection.

Confidence intervals around estimates are important and provide a range in which the true estimate is likely to be captured. Figure A4.2 provides prevalence estimates (the bars) with 95% confidence intervals (the vertical lines) for selecting 10 women at random from Table A4.1. For example, if 0 out of ten women are anemic, the prevalence would be 0% and the 95% confidence interval would be (0%, 32.1%). The horizontal line at 52% represents the true prevalence of anemia in this group. Note that if 0 women would be found to be anemic, the 95% confidence interval would ***not*** capture the "true" prevalence. Ninety five percent of the samples taken from a population would have a 95% confidence interval that captured the true prevalence. Therefore, when a survey is performed and a 95% confidence interval calculated, it is likely that truth is captured in the confidence interval, but there is a small chance it does not. For example, if 0 out of 10 women are anemic, the 95% confidence interval would not include the "true" prevalence of 52%. However, as mentioned earlier (see Figure A4.1), the probability of selecting 0 out of 10 women being anemic was very low, only .06%. More likely a random selection of 10 women from this population would find between 2 and 8 to be anemic where the confidence intervals would capture the true prevalence.
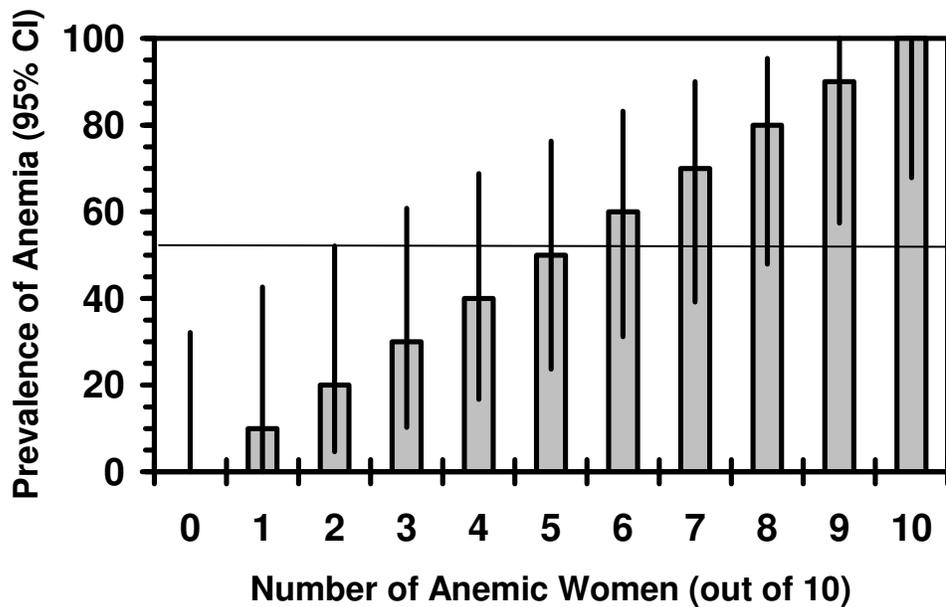
Figure A4.2 Prevalence and 95% confidence intervals for selecting between 0 and 10 anemic women out of 50 where the true prevalence is 52%.

(Note: calculation of confidence interval based on modified Wald procedure and does not take into account the finite population correction factor)

A4.3 Sampling from Large Populations

At this point we have described the use of simple random and systematic sampling to select from a list of eligible individuals. When performing a survey at a national or sub-national level, it is very unlikely that a list of eligible individuals would be available for sampling purposes. However, even if such a list were available, for a large geographic area, using simple random or systematic sampling might be too costly because those selected would likely be widely geographically dispersed. Therefore, most surveys performed in large geographic areas use a two-stage sampling procedure. At the first stage, a listing of geographic units is assembled. These geographic units are sometimes referred to as "enumeration units" or "census tracts" or might be a listing of municipalities (e.g., towns, villages, and cities). From this listing, a sampling procedure is used to determine which geographic units are to be included in the survey (selected geographic units are usually referred to as "clusters"). A more detailed description of selecting clusters can be found in Chapter 3. At the second stage, within each selected geographic unit or "cluster", an attempt is made to develop a list of eligible *units*, which could be

households in a household-based survey or individuals in a clinic-based survey, and a sampling procedure, perhaps simple random or systematic selection, is used to select those to be surveyed.

Appendix 5
Sample Size Tables

Sample sizes for estimating a proportion taking into account different design effects, confidence intervals, and confidence width. The most *commonly* used values are a 95% confidence interval, a DEFF of around 2, and width of ±5%, which is shown in Table A5.2. In Table A5.2, if it is estimated the proportion is 50% and the DEFF is 2, then the sample size is 769. Table A5.1 provides calculations for a *d* value of ±3% and Table A5.3 a *d* value of ±10%.

Table A5.1 Total sample size required for **95%** confidence interval with a width (*d*) of **±3%**.

Proportion (%)	Design Effect (DEFF)					
	1	**2**	**3**	**4**	**5**	**6**
10 or 90	384	769	1153	1537	1921	2305
20 or 80	683	1366	2049	2732	3415	4098
30 or 70	897	1793	2689	3586	4482	5378
40 or 60	1025	2049	3074	4098	5122	6147
50	1068	2135	3202	4269	5336	6403

Table A5.2 Total sample size required for **95%** confidence interval with a width (*d*) of **±5%**.

Proportion (%)	Design Effect (DEFF)					
	1	**2**	**3**	**4**	**5**	**6**
10 or 90	139	277	415	554	692	830
20 or 80	246	492	738	984	1230	1476
30 or 70	323	646	969	1291	1614	1937
40 or 60	369	738	1107	1476	1844	2213
50	385	769	1153	1537	1921	2305

Table A5.3 Total sample size required for **95%** confidence interval with a width (*d*) of **±10%**.

Proportion (%)	Design Effect (DEFF)					
	1	**2**	**3**	**4**	**5**	**6**
10 or 90	35	70	104	139	173	208
20 or 80	62	123	185	246	308	369
30 or 70	81	162	242	323	404	485
40 or 60	93	185	277	369	461	554
50	97	193	289	385	481	577

Appendix 6
Random Number Table

To use the random number table in Table A6.1, first choose a direction in which numbers will be read (down, up, left, or right). Next, close your eyes and point to a place on the random number table. The number closest to the point touched on the table is the starting point. Read the numbers in the direction decided upon ahead of time using the number of digits required.

Example: In the selection of households, it was determined that every 26th household should be included in the survey. To select the first house, a random number is selected from 1 to (and including) 26. For this example, it was decided to read the numbers downward from the starting point, and the starting point is the first number in the fourth column (8535). In this example, we only need to use the first two digits, 85. Reading down the column, the next number is 61, then 74, 69, 55, 90, 77, 38, 73, and finally 09. The value 9 is between 1 and 26 and therefore the first house to be sampled is the 9th household, and after that, every 26th household.

If more than four digits are needed for the selection process, the numbers in the next column can be used. For example, say a five-digit number is needed for selecting villages and cities from a cumulative population listing to be included in a cluster survey. The first number in the upper left-hand corner of the random number table could be read as 20,570, and, reading downward, the next number as 64,352, etc.

A number of programs can produce random number tables including OpenEpi (www.OpenEpi.com).

Table A6.1 Table of Random Numbers

2057	0762	1429	8535	9029	9745	3458	5023	3502	2436
6435	2646	0295	6177	2755	3080	3275	0521	6623	1133
3278	0500	7573	7426	3188	0187	7707	3047	4901	3519
7888	6411	1631	6981	1972	4269	0022	3860	1580	6751
4022	6540	7804	5528	4690	3586	9839	6641	0404	0735
0888	3504	2651	9051	5764	7155	6489	2660	3341	8784
0605	4640	8692	7712	9832	6607	0480	2557	3461	9755
4398	8857	0221	3844	1823	4407	5914	7545	2362	2428
7899	2623	9965	7366	0486	8185	5896	3985	3105	7210
5375	2213	8481	0919	2350	7310	7106	0046	1683	6269
1120	5436	8921	6457	8361	9849	9902	4244	2377	9213
4625	5978	5266	7521	8488	6854	9203	2598	2673	2399
5112	4318	5003	3532	6430	5679	5041	2108	1813	4235
3915	9380	3918	5957	3603	6553	6247	8907	5282	1106
9223	5629	6982	4138	2901	7592	1650	2580	5676	6470
0122	0620	2140	5291	8499	3653	1727	0453	3032	2902
4114	2462	2820	0414	7197	3854	2940	3500	8685	6131
0774	7788	5011	4971	0848	0748	7103	3262	5182	1185
1493	3425	0114	4662	0802	1125	8745	5513	9750	0695
5727	7577	8631	0759	5430	9953	1426	0405	2109	2304
5329	2475	8555	8172	1376	3459	6778	6917	0159	9635
7058	4886	2373	5937	9383	5763	8004	8602	2457	9134
0099	2200	2369	8140	4865	4874	4867	5206	0434	3845
0659	0499	3671	2771	2104	9275	2118	8024	1033	0529
1596	6230	3551	3506	5255	9108	0356	1225	1590	4395
0545	4817	9267	0371	5284	2221	0196	1096	4899	5525
6166	0733	6128	5076	1275	0830	7068	3991	3074	2971
4117	9128	4402	2038	5331	7530	7453	0957	1607	6088
8288	2958	3952	3918	5441	9365	9416	4897	7032	2475
1577	9415	2710	8305	6371	6065	0247	1365	8204	0017
9777	9879	4107	4685	8972	9948	4715	7049	0376	0882
7306	1399	4910	0074	9746	3203	9962	6041	4534	0062
8830	8623	7382	3570	5267	2355	7382	0171	7830	7416
0649	6675	6679	6681	7699	0805	5125	3177	7846	6891
4000	0001	3982	6805	6783	4715	6524	8615	3841	5508
2282	5183	4865	6339	8762	8930	4058	0575	1083	2992
8197	8865	0619	5693	4251	1158	1801	2006	1051	6518
4222	6138	0639	6599	0124	6559	4921	5162	7018	2384
1331	1221	3024	3839	2581	0017	4060	4781	6342	2808
9245	8353	5373	1085	2086	3356	3530	7662	7278	7993
9405	7493	9184	0309	0636	7980	3496	8936	4313	6417
2824	0568	0885	9270	4830	5958	2679	5622	3936	8687
1421	7905	1374	5079	5885	4803	4167	2356	0106	6433
8862	5634	9431	1435	3847	1364	7439	1254	3347	7625
0633	2973	0255	8997	5394	6188	2572	3427	4085	4168

Appendix 7
Guidelines for Interviewers

A7.1 Human Rights and Consent Issues

Before performing any survey, care must be taken to assure and respect the rights of individuals. In each country, guidelines concerning the rights of individuals should be followed. There may be a committee that must review the survey procedures and provide approval before the survey can be initiated. In some areas it may be necessary to obtain written consent from participants, or for children, from the parents/caretakers to allow their children to participate in the survey. Confidentiality of results also needs to be considered. Feedback to the individuals with significant health problems, such as severe anemia, must be provided.

A7.2 Conducting interviews

Successful interviewing is an art and should not be treated as a mechanical process. Each interview is a new source of information, so make it interesting and pleasant. The art of interviewing develops with practice but there are certain basic principles that should be followed by every successful interviewer. In this section you will find a number of general guidelines on how to build rapport with a respondent and conduct a successful interview.

The interviewer and the respondent are strangers to each other and one of the main tasks of an interviewer is to establish rapport. The respondent's first impression of you will influence her willingness to co-operate with the survey. Be sure that your appearance is neat and your manner friendly as you introduce yourself. Carry a visible identification tag, the more official and formal looking this tag is the more seriously you will be taken. It also helps to use uniform like clothing that links the field worker with the health system.

A7.2.1   Make a Good First Impression

When first approaching the respondent, do your best to make him or her feel at ease. With a few well-chosen words you can put the respondent in the right frame of mind for the interview. Open the interview with a smile and greeting and then proceed with your introduction.

A7.2.2   Always have a Positive Approach

Never adopt an apologetic manner, and do not use words, as "Are you too busy?" "Would you spare a few minutes?" or "Would you mind answering some questions?" Such questions invite refusal before you start. Rather, tell the respondent, "I would like to ask you a few questions", or "I would like to talk with you for a few moments".

A7.2.3   Stress Confidentiality of Responses when Necessary

If the respondent is hesitant about responding to the interview or asks what the data will be used for, explain that the information you collect will remain confidential, no individual names will be used for any purpose and that all information will be pooled to write a report. Also, you should never mention other interviews or show completed questionnaires to other interviewers or supervisor in front of a respondent or any other person.

A7.2.4   Answer Any Questions from the Respondent Frankly

Before agreeing to be interviewed, the respondent may ask you some questions about the survey or how she was selected to be interviewed. Be direct and pleasant when you answer. However, if she asks questions about medical or other issues, tell her that you will try to answer her questions after you have finished the interview.

The respondent may ask about the length of the interview and you should tell her how long it will take. Indicate your willingness to return at another time if it is inconvenient for her to sit for the interview at that very moment.

A7.2.5   Interview the Respondent Alone

The presence of a third person during an interview can keep you from getting frank, honest answers from a respondent. It is, therefore, very important that the individual interview be conducted privately and that all questions are answered by the respondent herself/himself.

If other people are present, explain to the respondent that some of the questions must be answered by her only and ask where the best place you can talk with her alone is. Sometimes asking for privacy will make others more curious, so they will want to listen; you will have to be creative. Establishing privacy from the beginning will allow the respondent to be more attentive to your questions.

If it is impossible to get privacy, you may have to carry out the interview with the other people present. However, try to separate yourself and the respondent from the others as much as possible. Extra effort should be made to gain privacy if the other person is a man. Make sure your time and the time of the respondent are not wasted but dedicate enough time that the subject feels treated as a human being.

A7.3 Tips for Successful Interview

A7.3.1   Be Neutral Throughout the Interview

Most people are polite and will tend to give answers that they think you want to hear. It is therefore very important that you remain absolutely neutral as you ask the questions. Never either by the expression on your face or by the tone of your voice, allow the respondent to think that she has given the "right" or "Wrong" answers to the question. Never appear to approve or disapprove of any of the respondent's replies.

The questions are all carefully worded to be neutral. They do not suggest that one answer is more likely or preferable to another answer. If you fail to read the complete question, you may destroy that neutrality.

If the respondent gives an ambiguous answer, try to probe in a neutral way, asking questions such as:

"Can you explain a little more?"
"I did not quite hear you, could you please tell me again?"
"There is no hurry. Take a moment to think about it"

A7.3.2   Never Suggest Answers to the Respondent

If a respondent's answer is not relevant to a question, do not probe her by saying something like "I suppose you mean that ...... Is that right?" In many cases, she will agree with your interpretation of her answer, even when that is not what she meant. Rather, you should probe in such a manner that the respondent herself comes up with the relevant answer. For some survey questions you may be allowed to read out the list of coded answers to the respondent.

A7.3.3   Do not Change the Wording or Sequence of Questions

The wording of the questions and their sequence in the questionnaire must be maintained. If the respondent has misunderstood the question, you should repeat the question slowly and clearly. Provide only the minimum information required to get an appropriate response.

A7.3.4   Handle Hesitant Respondents Tactfully

There will be situations where the respondent simply says "I don't know", gives an irrelevant answer, acts very bored or detached, contradicts something she has already said, or refuses to answer the question. In these cases you must try to re-interest her in the conversation. For example, if you sense that she is shy or afraid, try to remove her shyness or fear before asking the next question.

If the woman is giving irrelevant or elaborate answers, do not stop her abruptly or rudely, but listen to what she has to say. Then try to steer her gently back to the original question. A good atmosphere must be maintained throughout the interview. The best atmosphere for an interview is one in which the respondent sees the interviewer as a friendly, sympathetic and responsive person who does not intimidate her, and to whom she can say anything without feeling shy or embarrassed. As indicated earlier, the major problem in controlling the interview may be one of privacy. This problem can be prevented if you are able to obtain a private area in which to conduct the interview.

If the respondent is reluctant or unwilling to answer a question, try to overcome her reluctance, explaining once again that the same question is being asked of women all over the country and that the answers will be merged together.

If she still refuses, simply write REFUSED next to the question and proceed as if nothing had happened. If you have successfully completed the interview, you may try to obtain the missing

information at the end, but do not push too hard for an answer. Remember, the respondent cannot be forced to give an answer.

A7.3.5   Do not Form Expectations

You must not form or express any opinions about the ability and knowledge of the respondent because this can influence the interview. The respondent, believing that you are different from her, may be afraid or mistrustful. You should always behave and speak in such a way that she is put at ease and is comfortable talking to you.

A7.3.6   Do not hurry the Interview

Ask the questions slowly to ensure the respondent understands what she is being asked. After you have asked a question, pause and give her time to think. If the respondent feels hurried or is not allowed to formulate her own opinion she may respond with "I don't know" or give up the interview. Say to the respondent, "There is no hurry. Your opinion is very important so consider your answers carefully".

Appendix 8
Example Tables

In this Appendix are examples of tables for presenting results on some of the indicators discussed in this manual. These are just examples and each country may need to adapt the tables to their own needs. In addition, there will be many other tables necessary for a survey report not shown here. In general we recommend that tables should have confidence intervals taking into account the survey design, but note that not all of the tables presented here include confidence intervals; sometimes the confidence interval and the design effect may be provided in the text for the overall prevalence. These tables could be adapted for use in other age groups and other indicators.

Table A8.1 Urinary Iodine in non-pregnant women of childbearing age (15-49.9 years old), National Micronutrient Survey, *Country, Year*

	N	%<50 µg/L[1]	%<100 µg/L[2]	%≥100 µg/L	%>300 µg/L	Median µg/L[3]
Age group (years)						
15-19.9	75	1.9 (0.4, 7.8)	8.4 (3.7,18.0)*	91.6 (82.0, 96.3)*	39.6 (29.7, 50.4)*	269.9
20-29.9	121	4.2 (1.7, 9.9)	20.6 (13.9, 29.5)*	79.4 (70.5, 86.1)*	26.9 (17.8, 38.3)*	193.1
30-39.9	81	8.9 (3.4, 21.6)	22.9 (14.1. 35.0)*	77.1 (65.0, 85.9)*	26.7 (16.9, 39.7)*	202.2
40-49.9	53	4.5 (1.0, 17.5)	10.3 (4.4, 22.1)*	89.7 (77.9, 95.6)*	51.5 (36.4, 66.3)*	306.2
Marital status						
Single/not married	138	1.6 (0.3, 7.4)	13.6 (7.6, 23.0)	86.4 (77.0, 92.4)	36.1(26.9, 46.5)	240.7
Married	176	7.1 (3.2, 14.9)	19.7 (12.8, 28.9)	80.3 (71.1, 87.2)	31.0 (23.4, 39.8)	203.6
Other	16	7.6 (1.0-40.8)	11.5 (2.6, 39.0)	88.5 (61.0, 97.4)	41.5 (18.5, 69.0)	315.0
Per capita monthly income						
<30 USD	36	0.0	2.1 (0.3, 14.7)*	97.9 (85.3, 99.7)*	36.9 (20.2, 57.4)	240.1
>30 USD	292	5.6 (2.8, 10.7)	18.8 (13.2, 26.0)*	81.2 (74.0, 86.8)*	33.5 (25.4, 42.6)	212.2
Education level of head of household						
None	75	3.4 (0.8, 14.0)	13.1 (7.2, 22.7)	86.9 (77.9, 92.8)	24.4 (15.3, 36.6)	226.0
Primary	134	6.0 (2.8,12.2)	17.6 (10.9, 27.3)	82.4 (72.7, 89.1)	36.6 (26.6, 48.0)	238.1
>Primary	119	4.7 (2.0, 10.7)	18.6 (11.3, 29.1)	81.4 (70.9, 88.7)	37.0 (26.7, 48.5)	210.9
HH Salt iodine Level (ppm)						
None	10	0.0*	39.2 (13.2, 73.2)*	60.8 (26.8, 86.8)*	19.5 (5.2, 51.5)*	143.0
0.1-14.9	114	8.7 (3.6, 19.4)*	30.4 (20.5, 42.6)*	69.6 (57.4, 79.5)*	16.7 (10.1, 26.5)*	146.5
15-29.9	204	13.4 (5.4, 29.5)*	22.2 (11.4, 38.9)*	77.8 (61.1, 88.6)*	27.3 (13.3, 47.9)*	212.2
30–69.9	170	0.8 (0.1, 6.1)*	6.5 (3.2, 12.7)*	93.5 (87.3, 96.8)*	35.5 (25.7, 46.6)*	257.2
≥70	65	1.5 (0.2, 11.0)*	4.5 (1.0, 17.5)*	95.5 (82.5, 99.0)*	70.2 (58.5, 79.7)*	454.8
National	**330**	**4.9 (2.5, 9.5)**	**16.8 (11.9, 23.2)**	**83.2 (76.8, 88.1)**	**33.6 (26.3, 41.8)**	**222.9**

National data is weighted for proportions to account for survey design, however, median values are unweighted,

* P<0.05 comparing against the demographic characteristic, e.g., by age, income, salt iodine levels.

1 WHO goal: <20%;

2 WHO goal: <50%;

3 WHO goal: median 100 to 300 µg/L

Table A8.2   Households (HH) with salt available for testing and with presence of iodine based on a rapid salt iodine test kit, National Micronutrient Survey, *Country Year*.

Household Characteristic	N	HH with salt (%)	Results with color change* (%)**
SES			
Low	831	80.5	92.2
Moderate	517	92.6	91.9
High	101	99.3	87.4
Residence			
Urban	175	92.4	91.8
Rural	1286	85.3	91.7
Region			
Northern	490	87.1	94.1
Central	497	89.5	89.9
Southern	474	82.9	92.9
National	**1461**	**86.1**	**91.7**

*A change in color is an estimate of the presence of iodine in the salt using the MBI kit.
**Based on households that had salt available for testing.

Table A8.3   Households (HH) with various levels of iodine in salt and median iodine levels (ppm) based on salt titration analysis, National Micronutrient Survey, *Country Year*.

Household Characteristic	N	Proportion of households meeting WHO recommendations for elimination of IDD (≥15 ppm) (95% CI)		
		>15 ppm	<15 ppm	Median PPM
Per capita monthly income				
<30 US Dollars	45	48.5 (24.2, 73.4)	51.5 (26.6, 75.8)	19.0
>30 US Dollars	341	60.3 (52.0, 68.0)	39.7 (32.0, 48.0)	31.1
Education level of head of household				
None	100	50.2 (37.8, 62.5)	49.8 (37.5, 62.2)	16.7
Primary	123	56.3 (46.2, 65.8)	43.7 (34.2, 53.8)	28.6
>Primary	163	59.0 (56.7, 66.7)	41.0 (33.3, 49.3)	37.9
National	**390**	**59.3 (51.1, 67.0)**	**40.7 (33.0, 48.9)**	**30.7**

Figure A8.1 Percentage of households with various levels of iodine (ppm) in salt, National Micronutrient Survey, *Country Year***.**
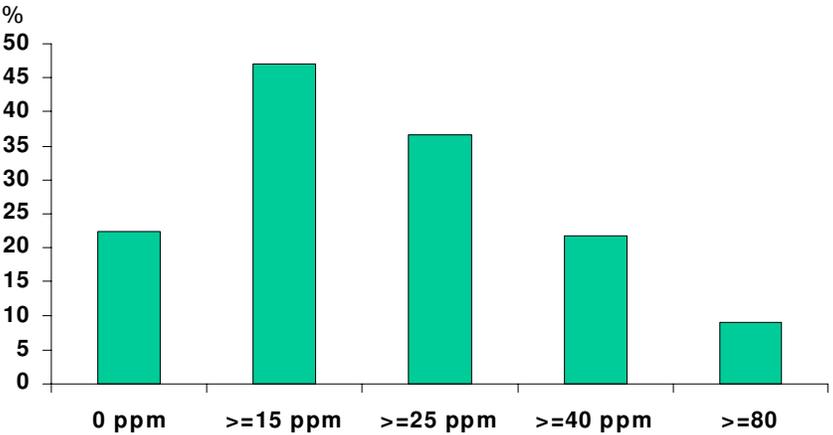
National data is weighted to account for survey design.

Table A8.4 Prevalence of low serum retinol levels and mean serum retinol levels among preschool children (6-36 months), National Micronutrient Survey, *Country Year*.

Characteristics of Preschool children	N	<10 µg/dl	<20 µg/dl	<30 µg/dl	Mean serum retinol (µg/dl)
Age Group (mos)					
6-11.9	97	4.8	59.7	94.6	19.1
12-23.9	191	6.8	58.8	87.7	20.1
24-35.9	170	9.7	61.1	94.4	19.1
Sex					
Male	228	9.3	62.6	92.6	19.3
Female	248	5.6	55.9	89.9	19.9
SES					
Low	258	6.6	60.4	92.5	19.4
Moderate	181	9.5	63.6	93.7	18.8
High	36	3.0	30.3	72.2	24.8
Residence					
Urban	38	12.1	58.0	90.2	20.2
Rural	438	6.9	59.3	91.3	19.6
Region					
Northern	149	3.4	40.3	79.2	24.2
Central	175	4.6	63.4	90.9	19.5
Southern	152	10.5	59.9	94.1	18.7
National	**476**	**7.4**	**59.2**	**91.2**	**19.6**

The header "Prevalence (%) of serum retinol:" spans the columns <10 µg/dl, <20 µg/dl, and <30 µg/dl.

Table A8.5. Prevalence of low serum retinol levels and mean serum retinol levels among women of childbearing age (15-45 years), National Micronutrient Survey, *Country Year*.

Characteristics of Women	N	Prevalence (%) of serum retinol:			Mean serum retinol (μg/dl)
		<10 μg/dl	<20 μg/dl	<30 μg/dl	
Age Group (years)					
15-19	100	0.0	55.7	91.4	19.9
20-29	184	3.3	61.3	88.5	19.8
30-39	135	7.2	51.9	93.2	20.4
40-45	45	18.3	58.6	81.9	20.3
Education					
None	92	12.5	55.5	89.2	20.0
1-5	163	5.0	60.4	89.8	19.4
6-8	143	1.2	56.4	91.6	20.3
>8	65	0.0	53.9	87.7	21.5
SES					
Low	250	6.4	55.3	87.8	20.4
Moderate	170	4.4	60.6	93.1	19.4
High	42	0.0	57.3	92.6	20.2
Residence					
Urban	56	2.4	69.2	94.4	18.3
Rural	408	5.5	55.4	89.2	20.3
Region					
Northern	167	1.8	37.7	89.2	22.3
Central	168	3.6	58.3	92.9	19.8
Southern	129	7.0	60.5	87.6	19.7
National	**464**	**5.1**	**57.4**	**89.9**	**20.0**

Table A8.6 Coverage of vitamin A supplements and months since last dose among preschool children (6-36 months), National Micronutrient Survey, _Country Year_.

Characteristics of Preschool Children	N	Percent ever received vitamin A supplement	Months since last dose		
			Median	<6 mos	<12 mos
Age Group (mos)					
6-11.9	116	70.6	3	69.2	-
12-23.9	219	91.3	4	60.7	83.4
24-35.9	184	90.9	9	40.4	64.1
Sex					
Male	256	85.8	5	54.5	72.9
Female	284	86.7	4	56.6	74.4
SES					
Low	290	85.3	4	56.6	72.7
Moderate	208	88.9	5	59.2	76.1
High	40	79.1	9	30.2	70.2
Residence					
Urban	42	100.0	9	42.3	72.7
Rural	498	85.0	4	57.0	73.9
Region					
Northern	167	90.4	6	54.0	79.5
Central	207	82.6	5	50.2	70.5
Southern	166	88.6	4	60.7	75.2
National	**540**	**86.3**	**5**	**55.6**	**73.7**

Table A8.7 Coverage of vitamin A supplements within the first two months after their last delivery* among women of childbearing age (15-45 years), National Micronutrient Survey, *Country Year*.

Characteristics of women	N	Percent reporting received vitamin A supplement within 2 mos. of delivery*
Age Group (years)		
15-19	38	17.4
20-29	193	37.9
30-39	149	35.6
40-45	47	34.9
Education		
None	103	24.7
1-5	153	37.3
6-8	127	35.7
>8	44	52.8
SES		
Low	243	31.0
Moderate	150	40.3
High	32	42.1
Residence		
Urban	44	43.1
Rural	383	33.9
Region		
Northern	159	49.7
Central	140	33.6
Southern	128	32.8
National	**427**	**34.9**

*Restricted to women who had given birth within the previous two years.

Table A8.8   Prevalence of anemia (hemoglobin <11 g/dL) and mean hemoglobin among children 6-59.9 months, National Micronutrient Survey, *Country Year*.

Characteristics of Children	N	Percent anemic (95% CI)	Mean hemoglobin g/dl (95% CI) [SD]
Age Group (months)			
6-11.9	35	90.7 (78.5, 96.3)*	10.2 (9.9, 10.6) [1.06]*
12-23.9	54	47.0 (34.1, 60.2)*	10.9 (10.5, 11.3) [1.06]*
24-35.9	55	29.0 (18.4, 42.7)*	11.4 (11.0, 11.8) [0.88]*
36-47.9	67	27.0 (16.3, 41.3)*	11.6 (11.4, 11.9) [1.01]*
48-59.9	36	21.0 (9.9, 39.3)*	11.5 (10.9, 12.0) [1.35]*
6-23.9	89	66.4 (54.2, 76.8)*	10.6 (10.3, 10.9) [1.13]
24-59.9	158	26.3 (19.1, 34.9)*	11.5 (11.3, 11.7) [1.05]
Sex			
Male	130	39.7 (29.8, 50.5)	11.1 (10.9, 11.3) [1.05]
Female	117	43.4 (32.1, 55.5)	11.2 (10.9, 11.5) [1.25]
Average per capita monthly income within HH			
<30 USD	21	47.8 (26.6, 69.8)	10.7 (9.9, 11.5) [1.64]
>30 USD	224	40.7 (32.6, 49.3)	11.2 (11.0, 11.4) [1.09]
Education Level of Head of Household			
None	40	24.5 (11.4, 45.1)	11.6 (10.9, 12.3) [1.27]
Primary	83	51.1 (36.3, 65.8)	11.0 (10.7, 11.3) [1.28]
More than Primary	122	40.3 (30.9, 50.5)	11.2 (10.9, 11.4) [0.96]
National	**247**	**41.5 (34.2, 49.3)**	**11.2 (11.0, 11.3) [1.15]**

*P<.01 overall between age groups

Table A8.9 Prevalence of anemia (hemoglobin <12 g/dL) and mean hemoglobin among non-pregnant women of childbearing age (15-49.9 years), National Micronutrient Survey, *Country Year*.

Characteristics of Women	N	Percent anemic (95% CI)	Mean hemoglobin g/dl (95% CI) [SD]
Age Group (years)			
15-19.9	81	39.6 (28.5, 51.8)	12.1 (11.8, 12.4) [1.21]
20-29.9	127	36.3 (28.1, 45.4)	12.2 (12.0, 12.4) [1.10]
30-39.9	84	37.8 (28.9, 47.6)	12.2 (12.0, 12.4) [0.98]
40-49.9	53	45.4 (31.6, 60.1)	12.0 (11.7, 12.4) [1.28]
Marital Status			
Single (never Married)	151	38.3 (31.0, 46.1)	12.2 (12.0, 12.4) [1.18]
Married	170	37.8 (29.9, 46.4)	12.2 (12.0, 12.4) [1.10]
Other	16	51.7 (26.3, 76.3)	11.8 (11.4, 12.3) [0.95]
Average per capita monthly income within HH			
<30 USD	36	40.1 (26.7, 55.1)	12.1 (11.9, 12.4) [1.14]
>30 USD	316	38.6 (32.8, 44.8)	12.2 (12.0, 12.3) [1.13]
Education Level of Head of Household			
None	82	35.3 (24.7, 47.7)	12.3 (12.0, 12.5) [0.99]
Primary	143	44.3 (36.5, 52.4)	12.1 (11.9, 12.3) [1.20]
More than Primary	127	34.8 (25.4, 45.7)	12.1 (11.8, 12.4) [1.13]
National	**352**	**38.8 (33.3, 44.6)**	**12.2 (12.0, 12.3) [1.13]**

Table A8.10 Prevalence of iron deficiency (serum ferritin <12 µg/L) among children 6-59.9 months with a normal CRP (<5 mg/L), National Micronutrient Survey, *Country Year.*

Characteristics of Children	Prevalence (%) of iron deficiency (ID)			
	With a Normal CRP		Ignoring CRP	
	N	Prev. % (95% CI)*	N	Prev. % (95% CI)*
Age Group (months)				
6-11.9	2	-	3	-
12-23.9	33	23.1 (11.1, 41.9)	39	19.7 (9.7, 35.7)
24-35.9	48	29.1 (15.2, 48.5)	51	26.0 (14.2, 42.8)
36-47.9	57	10.9 (4.7, 23.3)	59	10.7 (4.7, 22.5)
48-59.9	31	15.8 (4.3, 43.9)	31	15.8 (4.3, 43.9)
6-23.9	35	21.8 (10.3, 40.4)	42	18.3 (8.8, 34.3)
24-59.9	136	17.8 (11.7, 26.1)	141	16.8 (11.1, 24.6)
Sex				
Male	88	21.7 (12.1, 35.7)	93	19.9 (11.1, 32.9)
Female	83	15.2 (8.5, 25.8)	90	14.3 (8.2, 23.9)
Average per capita monthly income within HH				
<30 USD	17	35.3 (13.4, 65.9)	17	35.3 (13.4, 65.8)
>30 USD	153	16.8 (11.1, 24.6)	165	15.3 (10.1, 22.6)
Education Level of Head of Household				
None	31	15.5 (6.2, 33.9)	32	15.1 (6.0, 33.1)
Primary	61	22.5 (12.9, 36.2)	64	21.1 (11.9, 34.7)
More than Primary	78	16.4 (9.5, 26.8)	86	14.8 (8.7, 24.1)
National	**171**	**18.5 (12.9, 25.9)**	**183**	**17.1 (11.8, 24.1)**

Table A8.11 Prevalence of iron deficiency anemia (hemoglobin <11 g/dL and serum ferritin <12 µg/L) among those with a normal CRP (≤5 mg/L) and ignoring CRP results, children 6-59.9 months, National Micronutrient Survey, *Country Year*.

Characteristics of Children	Prevalence (%) of iron deficiency anemia (IDA)			
	Normal CRP (≤5 mg/L)		Ignoring CRP	
	N	Prev. % (95% CI)*	N	Prev. % (95% CI)*
Age Group (months)				
6-11.9	2	-	3	-
12-23.9	31	8.0 (1.9, 28.2)	37	6.8 (1.7, 23.2)
24-35.9	47	9.8 (2.1, 35.6)	50	9.1 (1.9, 33.9)
36-47.9	56	3.1 (0.7, 12.2)	57	3.0 (0.7, 11.6)
48-59.9	31	13.6 (3.1, 43.8)	31	13.6 (3.1, 43.8)
6-23.9	33	7.6 (1.8, 26.9)	40	6.3 (1.6, 22.1)
24-59.9	134	7.7 (3.4, 16.5)	138	7.5 (3.3, 16.1)
Sex				
Male	86	11.0 (4.1, 26.2)	91	10.4 (3.9, 24.9)
Female	81	4.3 (1.3, 13.3)	87	4.1 (1.2, 12.4)
Average per capita monthly income within HH				
<30 USD	17	9.4 (1.2, 47.4)	17	9.4 (1.2, 47.4)
>30 USD	149	7.6 (3.4, 16.0)	160	7.1 (3.2, 15.1)
Education Level of Head of Household				
None	30	0.0	31	0.0
Primary	61	13.4 (5.4, 29.8)	63	13.1 (5.3, 29.2)
More than Primary	75	5.5 (2.3, 12.5)	83	4.9 (2.1, 11.2)
National	**167**	**7.7 (3.6, 15.8)**	**178**	**7.3 (3.4, 15.0)**

National data is weighted to account for survey design.
*Children 6-59.9 months: iron deficiency anemia defined as a serum ferritin <15 µg/L and hemoglobin <12 g/dL.

Table A8.11 **Prevalence of an elevated CRP (>5 mg/L) among children 6-59.9 months, National Micronutrient Survey, *Country Year*.**

Characteristics of Children	N	Percent with elevated CRP (95% CI)
Age Group (months)		
6-11.9	3	30.4 (3.4, 84.3)
12-23.9	39	11.2 (4.5, 25.0)
24-35.9	51	6.3 (1.8, 19.5)
36-47.9	59	4.5 (1.1, 16.4)
48-59.9	31	0.0 (-, -)
6-23.9	42	12.5 (5.2, 27.1)
24-59.9	141	3.9 (1.6, 9.3)
Sex		
Male	93	3.8 (1.3, 10.7)
Female	90	7.5 (3.4, 15.8)
Average per capita monthly income within HH		
<30 USD	17	0.0 (-, -)
>30 USD	165	6.3 (3.5, 11.1)
Education Level of Head of Household		
None	33	2.3 (0.3, 16.7)
Primary	64	4.5 (1.3, 14.5)
More than Primary	85	8.2 (4.1, 15.4)
National	**183**	**5.6 (3.2, 9.9)**

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