Malaria Indicator Survey

Guidelines for Sampling for the Malaria Indicator Survey

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I. GENERAL PRINCIPLES FOR SAMPLING FOR MALARIA INDICATOR SURVEYS

All large-scale sampling activities should be guided by a number of general principles to achieve consistency and the best quality in survey results. This manual presents general guidelines on sampling for the Malaria Indicator Survey (MIS), although some modifications may be required for country-specific situations.

Survey coverage

An MIS sample should cover 100 percent of the target population. The target population depends on the malaria endemicity (see Section 2 below) and may be the entire country, (e.g., all malarious areas for a national survey, or selected regions or malaria-program areas for a sub-national survey). The general sampling principles are the same for each type of survey. For both national and sub-national surveys, exclusions may be necessary because of extreme inaccessibility.

Probability sampling

Scientific probability sampling must be used. A probability sample is defined as one in which the units are selected with known and nonzero probabilities. This is the only way to get unbiased estimation and to be able to evaluate the sampling errors. The term excludes purposive sampling, quota sampling, and other uncontrolled non-probability methods because they cannot provide precision and/or confidence evaluation of survey findings.

Preexisting sampling frame

Since the construction of a new sampling frame is likely to be too expensive, an MIS should use an adequate preexisting sampling frame. This is possible for most countries where there has been a population census in recent years. However, an evaluation of the quality and the accessibility of the frame should be considered in the protocol of the survey. This may require the cooperation of the country's national bureau of statistics. If it is possible, an MIS could be integrated with an ongoing national survey program in the interest of economy and coordination. However, as the sampling frame should be limited to malaria endemic areas, local assistance with identifying and excluding areas without malaria from the sampling is advisable.

Simplicity of sampling design

In large-scale surveys, non-sampling errors are usually the most important sources of error and are expensive to control and difficult to evaluate. It is important to minimize this type of error in survey implementation. Therefore, the sampling design for MIS should be as simple and straightforward as possible to facilitate accurate implementation. ORC Macro's experience with Demographic and Health Surveys (DHS) shows that a two-stage sampling design is appropriate, as discussed in Section 8 of this manual.

In the sections that follow, the general MIS policy is described in relation to a number of specific aspects of sampling design and implementation.

II. TARGET POPULATION

MIS is designed to measure the following core Roll Back Malaria (RBM) indicators:

Household level:

- The proportion of households with at least one mosquito net and at least one insecticide-treated net (ITN)

Individual level:

- The proportion of children under five years of age who slept under an ITN the previous night
- The proportion of children under five years of age with fever in the last two weeks who received prompt and effective antimalarial treatment according to national policy
- The proportion of pregnant women age 15-49 who slept under an ITN the previous night
- The proportion of women who received intermittent preventive treatment (IPT) for malaria during their last pregnancy

The target population for households and individuals is limited to those at risk for malaria; therefore, the *target population* of individuals for MIS is defined as all women of reproductive age (i.e., 15-49 years old) and all children under age five living within malaria endemic or epidemic-prone areas.

The international collaboration for Mapping Malaria Risk in Africa (MARA) [www.mara.org.za] has developed a Climate Suitability Index to predict whether or not an area's climate is suitable for malaria transmission. The MARA superimposed a grid of 5 x 5 km squares on a map of middle and southern Africa. For each square, the MARA estimated a Climate Suitability Index on the basis of a model of temperature and rainfall determinants of the parasite's sporogenic cycle and mosquito's survival [1]. The Index describes the probability that the climate is suitable for *P. falciparum* transmission, and it varies continuously from 0 (i.e., probably unsuitable) to 1 (i.e., high probability the climate is suitable). Different cut-offs of the MARA index have been used to categorize areas as having no malaria transmission, low-intensity transmission or epidemic malaria transmission, and high-intensity transmission or endemic transmission. Researchers studying malaria mortality have used the MARA index to develop definitions of malaria transmission intensity: High-intensity transmission is defined as areas with a MARA Climate Suitability Index ≥0.75; and low-intensity transmission is defined as areas with a MARA index that is greater than zero, but <0.75 [2]. These cut-offs are the same as those used in the estimates of child malaria mortality developed by the Child Health Epidemiology Reference Group [3].

In the context of the MIS, the Climate Suitability Index could be used to determine whether an entire country should be considered at risk of malaria or just certain areas of the country. It is suggested that if more than 80 percent of a country's population lives in areas with a MARA index ≥0.75, the entire country should be considered to have high-intensity transmission and should be included in the survey (see Section 4 of this document for a list of malarious countries).

If a country has 80 percent or less of its population living in areas with a MARA index ≥0.75, then create two survey domains (see Section 3): One with low-intensity transmission and one with high-intensity transmission. To determine which areas have which level of transmission, use MARA maps, or the MARA databases that have data on the MARA Index down to the secondary administrative level, and local knowledge. Note that some countries in this group have sizeable populations with no malaria transmission; as mentioned above, these populations are not part of the target population and should not be surveyed.

III. SURVEY DOMAINS

To compare the survey results for different household characteristics (e.g., urban and rural areas, different administrative or geographical regions, high- and low-intensity malaria transmission regions, high and low levels of malaria programmatic activity), the target population is subdivided into *study domains*. It is expected that indicators will be tabulated at the national level as well as at the survey-domain level.

For a national survey for countries with endemic and/or epidemic-prone malaria throughout, the coverage should include the entire national territory without omission unless there are justifiable reasons for excluding certain areas. For countries that contain regions without malaria transmission that are excluded from the survey, these regions should constitute a coherent domain. A survey from which a number of scattered zones have been excluded is difficult to interpret and use. If a malaria program knows that there are malarious areas with very different levels of programmatic activity, then “level of programmatic activity” could be a characteristic used to define survey domains. Thus, a survey might measure malaria indicators separately for different parts of the country with different levels of program activity; also a single national estimate could be calculated.

If domain-level estimates are required, it is best to avoid a large number of domains because otherwise a very large sample size will be needed.

IV. SAMPLING FRAME

A *sampling frame* is a complete list of all sampling units that entirely cover the target population. The existence of a sampling frame allows a probability selection of sampling units. For a multi-stage survey, a sampling frame should exist for each stage of selection. The availability of a suitable sampling frame is a major determinant of the feasibility of conducting an MIS survey. This issue should be addressed in the earliest planning for a survey. A sampling frame could be either, an existing sampling frame, an existing master sample, or a sample of a previously executed survey of sufficiently large sample size, which allows for the selection of subsamples of the desired size for the MIS. The best frame is the list of *enumeration areas* (EAs) from a recently completed population census.

In most cases, an area sampling frame, which is a list of the EAs in a complete census, is available. This list should be thoroughly evaluated before it is used. The sampling frame used for the MIS should be as up-to-date as possible. It should cover the whole country or subnational area included in the survey, without omission or overlap. Maps should exist for each area unit or at least groups of units with clearly defined boundaries. Each area unit should have a unique identification code or a series of codes that, when combined, can serve as a unique identification code. Each unit should have at least one measurement of size estimate (e.g., population and/or number of households). If other characteristics of the area units (e.g., socioeconomic level) exist, they should be evaluated and retained because they can be used for stratification.

Regions within countries without endemic or epidemic-prone malaria should either be excluded from the sampling frame of EAs or treated as a separate domain. However, in practice, this task may prove challenging because boundaries of malaria endemicity are not always clearly defined or known. In an attempt to assist with sampling frame development, countries within sub-Saharan Africa have been classified into the following categories: 1) countries with endemic and/or epidemic-prone malaria throughout; 2) countries with endemic and/or epidemic-prone malaria throughout, excluding readily identifiable regions within the Sahel or Sahara deserts; and 3) countries that contain malaria-endemic regions intermittently. The lists were derived from a review of maps that show the suitability of malaria transmission on the basis of climatic and entomological factors [6, 7].

1. It is recommended that for the following countries within sub-Saharan Africa with endemic and/or epidemic-prone malaria throughout, the sampling frame should cover the entire country (e.g., stratified by urban and rural residence).

Benin	Gabon	Mozambique
Burkina Faso	Gambia	Nigeria
Cameroon	Ghana	Senegal
Central African Republic	Guinea	Sierra Leone
Congo	Guinea Bissau	Togo
Côte d’Ivoire	Liberia	Uganda
Equatorial Guinea	Malawi	Zambia

2. The sampling frame for the following countries should include the whole country, except those areas within the Sahel/Saharan desert (e.g., stratified by urban and rural residence).

   Chad
   Mali
   Mauritania
   Niger
   Sudan

3. For the following countries, regions without endemic and/or epidemic-prone malaria should be excluded from the sampling frame, or treated as a separate domain (e.g., stratification by urban and rural residence should still be done). For some of these countries, simply excluding highland areas (e.g., with mean ambient monthly temperatures below 15˚ C) may suffice. Within others, advice from experts from the ministry of health, local universities, or resident experts in malaria, as well as information from the scientific literature and/or malaria risk maps should be sought in developing the most appropriate sampling frame. Note that countries outside sub-Saharan Africa will also require similar treatment to develop the most appropriate sampling frames:

   Angola
   Burundi
   Botswana
   Democratic Republic of the Congo
   Djibouti
   Eritrea
   Ethiopia
   Kenya
   Madagascar
   Namibia
   Rwanda
   Somalia
   South Africa
   Swaziland
   Tanzania
   Zimbabwe

A preexisting master sample, which is a random sample of all EAs, can be accepted only where there is confidence in the master sample design, including such detailed sampling design parameters as sampling method, stratification, and inclusion probability of the selected primary sampling unit. The task for the MIS survey is then to design a subsampling procedure, which produces a sample in line with MIS requirements. This will not always be possible; however, the larger the master sample is in relation to the desired MIS subsample, the more flexibility there will be for developing a subsampling design. A key question with a preexisting sample is whether the listing of dwellings/households is still current or whether it needs to be updated. If updating is required, use of a preexisting sample may not be economical. The potential advantages of using a preexisting sample are: 1) economy, and 2) increased analytic power through comparative analysis of two or more surveys. The disadvantages are: 1) the problem of adapting the sample to MIS requirements, and 2) the problem of repeated interviews with the same household or person in different surveys, resulting in respondent fatigue or contamination. One way to avoid this last problem is to keep just the primary sampling units and reselect the households for the MIS survey.

V. STRATIFICATION

Stratification is the process by which the survey population is divided into subgroups or *strata* that are as homogeneous as possible using certain criteria. *Explicit stratification* is the actual sorting and separating of the units into the specified strata; within each stratum, the sample is selected independently. *Systematic sampling* of units from an ordered list (e.g., with a fixed interval between selected households) can also achieve the effect of stratification. This is called implicit *stratification.*

The principal objective of stratification is to reduce sampling error. In a stratified sample, the sampling error depends on the population variance existing *within the strata* but not *between the strata*. For this reason, it pays to create strata with low internal variability, or high homogeneity. Another major reason for stratification is that, where marked differences exist between subgroups of the population (e.g., urban vs. rural areas), stratification allows flexible selection of the sample allocation and design separately for each subgroup.

Stratification should be introduced only at the first stage of sampling. At the dwelling/household selection stage, systematic sampling is used for convenience; however, no attempt should be made to reorder the dwelling/household list before selection in the hope of increasing the implicit stratification effect. Such efforts generally have a negligible effect.

Stratification could be single-level or multi-level. A single-level stratification is used to divide the population into strata according to certain stratification criteria. A multi-level stratification is used to first divide the population into first-level strata according to certain stratification criteria, and then to subdivide the first-level strata into second-level strata, and so on. A typical two-level stratification is region-urban/rural stratification. An MIS survey is usually multi-level stratified.

Strata should not be confused with survey domains. A survey domain is a population subgroup for which separate survey estimates are desired (e.g., urban areas/rural areas). A stratum is a subgroup of homogeneous units (e.g., subdivisions of an administrative region) in which the sample may be designed differently and is selected separately. Survey domains and strata could be the same but they need not be. For example, survey domains could be the first-level stratum in a multi-level stratification. A survey domain could consist of one or several lower-level strata. If only implicit stratification is used, then no explicit strata exist.

At a minimum, the MIS should use explicit stratification to create separate survey domains for urban and rural residence. Where possible, it may also prove useful to use explicit stratification to create specific domains for high- and low-intensity malaria transmission. Where data are available, explicit stratification could also be done on the basis of socioeconomic zones or more directly relevant characteristics (e.g., the level of female literacy or the presence of health facilities in the areas). These kinds of information could be obtained from administrative sources. Within each explicit stratum, the units can then be ordered according to location, thus providing implicit geographic stratification.

VI. SAMPLE SIZE DETERMINATION

The issue of sample size determination is only partly a technical one. Under the same survey conditions, the larger the sample size, the better the survey precision and the more elaborate the analyses that can be sustained. The challenge in deciding on the sample size for a survey is to balance the demands of analysis with the capability of the implementing organization and the constraints of funding.

An appropriate sample size for an MIS is the minimum number of persons (e.g., currently pregnant women, children under age five, young children who have been ill with fever, births in the two years preceding the survey) within malaria endemic or epidemic-prone areas for whom the desired precision can be achieved for core indicators, at the national level and at the domain level if there are domains. If the funding is fixed, the sample size is the maximum number of persons that the funding can cover. Precision at the national level is usually not a problem. In most cases, sample size is decided to guarantee precision at the domain level with appropriate allocation of the sample; therefore, apart from survey costs, the total sample size depends on the desired precision at the domain level and the number of domains.

If a unique *relative precision* (i.e., *relative standard error (RSE),* see note under Table 1.1 below) is desired for all domains, the domain sample size depends on the variability and the size of the domain. The total sample size is the sum of the sample sizes over all domains for which desired precisions are guaranteed. In Table 1.1 we give an example of the calculation of sample size in a domain according to different levels of desired relative precision for estimating the indicator: The proportion of women who had a birth in the two years preceding the survey who received IPT against malaria during the most recent pregnancy. If the domain size is large enough that the finite population correction is negligible, Table 1.1 gives the required gross sample size with estimated parameters from a DHS survey. The estimated parameters are the proportion of women who had a birth in the two years preceding the survey who received IPT against malaria during the most recent pregnancy, the design effect (Deft) and the assumed overall response rate for women, (e.g., which can usually be obtained from a DHS survey). For example, if we require a RSE of 12 percent, we should select 1524 households (e.g., enough to obtain 396 women ages 15-49 who had a birth in the two years preceding the survey) in this particular domain. Assuming a 90 percent response rate, we expect to obtain completed interviews with 356 women ages 15-49 who had a birth in the two years preceding the survey.

Table 1.1. Sample size for estimating the proportion of women who received IPT during the most recent pregnancy among women who had a birth in the two years preceding the survey

Estimated proportion	23.4%	Double-click to activate Excel. The green colored cells can be overwritten.		
Estimated Deft	1.25			
No.of births in last 2 yrs/HH	0.26			
Gross response rate	90.0%			
Relative Standard Error (RSE)	Sample Size (Individual)	Sample Size (Household)	95% confidence limits	
			Lower CL	Upper CL
15.0%	254	977	16.4%	30.4%
14.0%	290	1116	16.8%	30.0%
13.0%	337	1297	17.3%	29.5%
12.0%	396	1524	17.8%	29.0%
11.0%	470	1808	18.3%	28.5%
10.0%	569	2189	18.7%	28.1%
9.5%	630	2424	19.0%	27.8%
9.0%	703	2704	19.2%	27.6%
8.5%	787	3027	19.4%	27.4%
8.0%	889	3420	19.7%	27.1%
7.5%	1012	3893	19.9%	26.9%
7.0%	1160	4462	20.1%	26.7%
6.5%	1346	5177	20.4%	26.4%
6.0%	1579	6074	20.6%	26.2%
5.5%	1879	7227	20.8%	26.0%
5.0%	2274	8747	21.1%	25.7%
3.0%	6316	24293	22.0%	24.8%

Note for relative standard error: The RSE of an estimator is the ratio of its standard error over its estimated value. This measure is independent of the scale of the parameter to be estimated and therefore a unique RSE can be used for all indicators. 2**RSE* is the half-length of the *relative confidence interval*, with a confidence level of 95 percent of the estimated proportion *P*. The half-length of the confidence interval is 2**P***RSE*. For example, for *RSE*=0.12 and *P*=0.234, the half-length of the relative confidence interval is 0.24, while the half-length of the confidence interval is 0.056. This means that with a sample size of 396 women who had a birth in the two years preceding the survey or 1524 households, a confidence interval of *P* will have lower and upper confidence limits 0.178 and 0.290, respectively.

Note on the Deft: For cluster surveys, a 2-step process is commonly used to determine sample size. First, one determines an initial sample size by ignoring the clustering. Second, one calculates a final sample size by multiplying the initial sample size by the quantity $(\text{Deft})^2$. In the above example, if clustering is ignored, the initial sample size is 254 (e.g., after accounting for non-response). The final sample size is $254 * (1.25)^2$, or 396.

The estimated quantities at the top of the table can usually be obtained from previous surveys or from administrative records. The total sample size for a country with several domains is the sum of the sample sizes obtained in the above table for each domain. If the same precision is requested for all domains and the same level of malaria transmission applies to all domains, then the total sample size is the sample size calculated for one domain multiplied by the number of domains. With this example, the total sample size for a country having six domains with approximately the same level of malaria transmission and the same precision requested for each domain will need to be 9144 households. In the electronic version of this report, double clicking on the table will activate Excel; all parameters in the green-coloured cells can be overwritten for specific requirements.

Table 1.2 shows a similar example for the indicator: The proportion of children under five who slept under a mosquito net last night. The example shows the calculation of sample size in a domain according to different levels of desired relative precision (i.e., RSE) for estimating this indicator. With the same Deft and response rate, this example assumes that the proportion of children under five who slept under a mosquito net last night is much lower than the proportion of women who receive IPT against malaria during pregnancy (data from a DHS survey), but in this case the number of households needed depends on the average number of children under five per household. For example, if we require the same relative standard error of 12 percent, we need to select only 1182 households in this particular domain and we expect to obtain information about 925 children under five years of age.

Combined with the results in the first example, if we select 1524 households in this particular domain, we can guarantee a relative standard error of 12 percent for estimating both the proportion of women who had a birth in the two years preceding the survey who received IPT against malaria during the most recent pregnancy, and the proportion of children under age five who slept under a mosquito net last night. Therefore, for a country with six regions, a sample size of 9144 households can guarantee the same precision for each domain.

Table 1.2. Sample size for estimating the proportion of children under age five who slept under a mosquito net last night

Estimated proportion	10.5%	Double-click to activate Excel. The green colored cells can be overwritten.		
Estimated Deft	1.25			
# of Children -5/HH	0.87			
Gross response rate	90.0%			
Relative Standard Error (RSE)	**Sample Size (Individual)**	**Sample Size (Household)**	**95% confidence limits**	
			Lower CL	**Upper CL**
15.0%	658	756	7.4%	13.7%
14.0%	756	869	7.6%	13.4%
13.0%	877	1008	7.8%	13.2%
12.0%	1028	1182	8.0%	13.0%
11.0%	1224	1407	8.2%	12.8%
10.0%	1480	1701	8.4%	12.6%
9.5%	1640	1885	8.5%	12.5%
9.0%	1828	2101	8.6%	12.4%
8.5%	2049	2355	8.7%	12.3%
8.0%	2314	2660	8.8%	12.2%
7.5%	2632	3025	8.9%	12.1%
7.0%	3022	3474	9.0%	12.0%
6.5%	3504	4028	9.1%	11.9%
6.0%	4112	4726	9.2%	11.8%
5.5%	4893	5624	9.3%	11.7%
5.0%	5920	6805	9.5%	11.6%
3.0%	16444	18901	9.9%	11.1%

The domain sample sizes often need to be balanced between domains under budget constraints. In practice it is often the case that the total sample size is fixed according to funding available, and then the sample is allocated to each domain. In case of very tight budget constraints and approximately the same level of malaria prevalence, we may equally allocate the total sample to the domains (e.g., in this case small domains are oversampled). In some cases, we want to oversample a specific domain, for example, for conducting some in-depth analysis in a high-intensity malaria transmission region. The method, and the tables presented in the following section may be used to allocate the sample at the domain level because the domains are usually first-level strata. Regardless of the method used for allocation, the above calculation of domain sample size can give us an idea about the precision we may achieve in each domain with a given sample size.

VII. STRATUM SAMPLE ALLOCATION

Once the total sample size of a domain has been fixed, we need to appropriately allocate the sample to strata within the domain. This allocation is aimed at strengthening the sample efficiency at the domain level. Assuming a constant survey cost across strata within the domain, the optimum allocation of the sample depends on the stratum size and the stratum variability on the indicator to be estimated. *The optimum allocation is optimal for the indicator on which the allocation is based, but it may not be appropriate for another indicator.* For a multipurpose survey, if the strata are not too different in size, a safe allocation that is *good for all indicators* is a *proportional allocation,* with sample size proportional to the stratum size. This allocation introduces a constant sampling fraction across strata within the domain. Since the MIS is a multipurpose survey, a proportional allocation of the sample is recommended if the strata are not too different in size. If the strata sizes are very different, small strata may receive a very small sample size. If precisions are considered at the stratum level (e.g., if the strata are first-level strata of survey domains), a *power allocation* with an appropriate power value may be used to guarantee sufficient sample size in small strata. A power value of 1 gives proportional allocation, a power value of 0 gives *equal size allocation,* and a power value between 0 and 1 gives an allocation between proportional allocation and equal size allocation. In Table 1.3, we give an example of sample allocation in a domain of 9 strata with a proportional allocation. The minimum stratum sample size is 61 for stratum 7. The actual total sample size may be slightly different from the desired sample because of rounding.

Table 1.3. Sample size allocation—proportional allocation

Sample Size	1000	
Power Value	1.000	
Stratum	Proportion	Allocation
1	0.098	98
2	0.153	153
3	0.136	136
4	0.090	90
5	0.134	134
6	0.148	148
7	0.061	61
8	0.099	99
9	0.081	81

Note: The stratum measure of size could be *absolute size* or *relative size.* Here we used the relative size, which is the proportion of the stratum. To change the *sample size*, *power value, stratum,* and *proportion*, double click on the table to activate Excel.

If we impose a condition such that the sample size should not be smaller than 100 in each stratum, after trying various power values, we find that a power value of 0.19 is appropriate as shown in Table 1.4. In this case, we would have a minimum sample size of 100 for stratum 7. The small strata are oversampled compared with a proportional allocation. Oversampling some small strata is frequently encountered in sample allocation for domain-level strata if domain-level tabulations are required.

Table 1.4. Sample size allocation—power allocation

Sample Size	1000	
Power Value	0.190	
Stratum	Proportion	Allocation
1	0.098	109
2	0.153	119
3	0.136	116
4	0.090	108
5	0.134	116
6	0.148	118
7	0.061	100
8	0.099	109
9	0.081	105

The above discussion also applies to sample size allocation to first-level strata/domains in a country where the total sample size is fixed. A proportional allocation is good for all indicators and provides the best precision for the country as a whole; however, if comparisons across domains are required and the total sample size is limited, an equal size allocation is recommended. A power allocation is a compromise between the proportional allocation and the equal size allocation.

VIII. A TWO-STAGE SAMPLE SELECTION PROCEDURE

ORC Macro DHS program has developed a convenient and practical sample selection procedure on the basis of experience from past surveys—a two-stage systematic sampling procedure. In the first stage, every EA in the country within malaria endemic or epidemic-prone areas is assigned a measure of size equal to the number of households or the population in the EA. In each stratum, a sample of EAs with a predetermined sample size is then selected independently with probability proportional to this measure of size. In the selected EAs, a listing procedure is performed such that all dwellings and households are listed. This procedure is important for *correcting errors existing in the sampling frame, and it provides a sampling frame for household selection* (see details in Section 10 below and the *Household Listing Manual* in this MIS Basic Documentation package and the *Listing Manual for Demographic and Health Surveys* [6]). After a complete household listing is conducted in the EAs, a fixed number of households is selected by equal probability, systematic sampling in the selected EAs. In each selected household, a household questionnaire is completed to identify women ages 15-49 and children under five. (For details of systematic sampling, refer to [7] and [8].)

The implementation of a sample selection procedure involving the selection of an area sample is usually straightforward. Most countries possess convenient area sampling frames, generally in the form of the EAs defined during the most recent population census. These usually come with sketch maps and size estimates, and in principle, the EAs do not vary greatly in population size. However, in most countries, there are no satisfactory lists of dwellings and/or households in these EAs (e.g., no address system outside the more affluent parts of the cities). Survey personnel usually have to make their own lists, although sometimes they can share with other surveys or select a subsample from a master sample.

IX. SIZE OF THE SAMPLE TAKEN PER EA

After the total sample size has been fixed and before the selection of the EAs, we must decide on the number of households to be selected in each EA and then calculate the total number of EAs that need to be selected. The optimum number of households to be selected per EA depends on the variable under consideration, the size of the EA, and the relative sampling cost per EA and per household.

A larger sample size within each EA can reduce survey field costs, but it can also reduce the survey precision if the households are very similar on the variable under consideration within the EA. Since the EAs usually consist of geographically coherent households, experience shows that a strong homogeneity exists among the households within an EA (see [9]). Furthermore, because an MIS survey is multipurpose, it is suggested that a large sample size within each EA should be avoided. For a moderately average EA size of 100-300 households and a relative cost of 5 (e.g., the cost of household listing and mapping in an EA is 5 times the cost of interviewing a household), the optimum sample size ranges from 20 to 40 households (see [9]). Regarding the difference of relative cost between urban and rural EAs, a smaller sample size in urban EAs and a larger sample size in rural EAs are expected (e.g., 25 households per urban EA and 30 households per rural EA are average sample sizes for most of the DHS surveys). For details of size of sample taken per EA, refer to the *DHS Sampling Manual* [7] and optimum subsampling in Demographic and Health Surveys [9].

X. HOUSEHOLD LISTING OPERATION

After the EAs are selected, a complete listing of dwellings/households in the EAs is necessary before the selection of households. The listing operation consists of visiting each of the selected clusters, recording on listing forms a description of every structure together with the names of the heads of the households found in the structure, and drawing a location map of the cluster as well as a sketch map of the structures in the cluster. The listing operation represents an appreciable field cost, but there is no reliable method by which it can be avoided. The listing operation represents one of the most important bias correction procedures in the survey, especially when the sampling frame is out-of-date. The listing operation will provide complete information on the number of residential households, households occupied, and households vacant. These kinds of information are necessary for household selection to reduce non-sampling errors. Experience shows that more, rather than less, attention to the quality of listing operations is required if serious biases are to be avoided. In particular, the combination of listing, sampling, and interviewing into a single operation, conducted by the interviewer while moving over the sample area, is an unworkable operation. Even less acceptable is the attempt to avoid listing altogether by having interviewers create clusters as they go along, or select a sample at fixed intervals during a random walk up to a predetermined quota. Such methods are designed to eliminate conscious choice in selection, but they fail to meet the requirement that the sample be selected in such a way as to give a known and nonzero probability to every potential respondent. These methods represent a false economy. *It is more efficient to reduce the sample size and retain the listing operation.*

Listing costs can be reduced by using segmentation to decrease the size of some of the big EAs; however, segmentation generates its own costs, and skill in map making and map interpretation is required. For more details about segmentation, see Section 11 below. For more details about the listing operation, refer to the Listing Manuals [6 and MIS Basic Documentation].

XI. SEGMENTATION, MAPPING, AND LISTING

Census EAs are sometimes too large (e.g., up to 800 households) to be economically feasible for a single survey to undertake the listing of all households in the EAs. Such EAs need to be segmented into smaller areas for a further stage of area sampling before household listing begins. In some cases, the census maps are not accurate enough for the work of segmentation to be done in the office. A field operation may be needed to map and segment these oversized EAs. To better control the fieldwork, it is recommended that only the fieldwork coordinator or team supervisor has the authority to decide which EA should be segmented and how many segments will be created in the EA.

To segment an EA, a standard segment size should be adopted: typically, about 200 households would be an appropriate segment size if 25-30 households are to be selected in the entire EA. Segmentation becomes progressively more difficult as segments become smaller because there are not enough natural boundaries to delineate very small segments. Moreover, concentration of the sample into smaller segments increases the sampling error. Because neighbours' characteristics are correlated, a smaller segment captures less of the variety existing in the population, which leads to less efficient sampling. There is a point beyond which it is not useful to attempt further segmentation. As a general rule, the average segment size should not be less than 100 households.

The next step is segmentation. If it is possible, it is recommended that segments of approximately equal size be created. In most cases, segmentation can only be carried out in the field. Each selected EA, whether due for segmentation or not, should be visited to verify maps. When this has been done, the same team can proceed to create the designated number of segments and to delineate them clearly on the map of the unit. If size measures (e.g., the number of households) are required using a quick count, these can be obtained at the same time. For more details of the segmentation operation, see the Listing Manuals [6 and MIS Basic Documentation].

Selection of the sample segment in each segmented EA is the next step. It is important to prevent biased selection. Clear instructions on how to select the segment should be given to the team doing the segmentation in the field, together with necessary parameters (e.g., the random number). A probability proportional to segment size selection is recommended (see Listing Manuals [6 and MIS Basic Documentation] for more details). Furthermore, control procedures should be introduced to ensure that no conscious biased selection occurs.

The next step is mapping and listing. Mapping refers to drawing a sketch map of the selected EA or segment of an EA, that shows, to the extent possible, the location of the dwellings together with landmarks found in the EA. The listing should be on a dwelling and household basis (i.e., listing of inhabited dwellings together with all households residing in each dwelling), including dwellings where households are absent at the time of the visit by the listing team. The subsequent interview should cover the current occupants of the listed dwelling whether or not they occupied it at the time of listing. Normally, listing should not be done by the interviewers and for this reason, and logistical reasons, a gap of at least one month is to be expected. For more details, refer to the Listing Manuals [6 and MIS Basic Documentation].

XII. HOUSEHOLD SELECTION

Once the mapping and household listing operation is completed, the household lists should be sent to the central survey office for the selection of households. The recommended household selection procedure is equal probability, systematic sampling. This procedure consists of selecting the sample households from the listing with a random start by the following criteria:

(1) The first selected sample household is *k* (*k* is the serial number of the household in the listing) if and only if:

$$(k\text{-}1)/L < Random \leq k/L$$

(2) The subsequent selected households are those having serial numbers:

$$k + (j\text{-}1)*I, \text{ (rounded to integers)}$$

for $j = 2, 3, \dots n$; where L is the total number of households listed in the EA, *Random* is a random number between (0, 1), $I = L/n$ is the sampling interval, and n is the number of households to be selected in the EA.

It is important to note that the *Random* numbers should be different and independent from EA to EA. Usually an Excel worksheet is prepared for household selection. When household listing results are entered, the selected households will appear automatically in the designated places. ORC Macro has developed a variety of Excel templates for household selection to meet different requirements [10]. Table 1.5 gives a sample Excel template for household selection.

Table 1.5. Sample Excel template for household selection

EA ID Information		HHs Listed	# of HHs to be selected	Selection interval	Random (0-1)	HOUSEHOLD SELECTED														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
XXXX	XXXX	250	20	12.50	0.98385	13	25	38	50	63	75	88	100	113	125	138	150	163	175	188
XXXX	XXXX	234	20	11.70	0.61076	8	19	31	43	54	66	78	90	101	113	125	136	148	160	171
XXXX	XXXX	197	20	9.85	0.50400	5	15	25	35	45	55	65	74	84	94	104	114	124	134	143
XXXX	XXXX				0.00938															
XXXX	XXXX				0.36631															
XXXX	XXXX				0.75011															
XXXX	XXXX				0.07051															
XXXX	XXXX				0.70154															

Note: In the electronic version of this report, double clicking will display the whole spread sheet.

Though an equal probability, systematic sample is easy to select, centralization of the household selection is necessary so that the completeness of the household listing operation can be assessed by experienced survey staff. Discrepancies between the expected and the listed number of households must be evaluated. Problem areas should be revisited. Sampling fractions could also be readjusted so as to give the expected number of households. In cases where it is not feasible to centralize household selection, especially when regional household listing teams are employed and travel is difficult, supervisors could be trained to do the selection in the field; however, in this situation, the evaluation of the quality may not be possible.

XIII. THE HOUSEHOLD INTERVIEWS

While logistically more difficult, it is *strongly recommended* that the household interviews for the MIS survey be conducted during or right after the rainy season. If the household interviews are conducted during the dry season when mosquito nuisance is lowest, it is likely that reported household ITN possession and use will be underestimated. However, it should be expected that conducting the interviews during the rainy season will likely increase survey costs per EA; thus, the budget for the survey should be prepared accordingly. Conducting survey fieldwork during the rainy season may also render some remote areas more inaccessible; however, such inaccessible remote areas should be included in the survey if at all possible to avoid selection bias.

After the selection of households, the interviewing team will be sent to the EAs and an assigned workload for visiting the selected households will be given to each interviewer. The interviewer must visit only the households she has been assigned, and she does not have the right to change/replace a previously selected household. Any unusual circumstances (e.g., dwellings not found, destroyed, or vacant) must be properly documented and reported.

Once the interviewer locates an assigned household, after careful verification, the interviewer will begin with the household interview; listing household members and visitors; identifying eligible respondents for the individual interview; and asking questions about household characteristics and mosquito nets that the household has. Eligible women are defined as usual residents of the household who are in the specified age group (i.e., 15-49) and non-usual residents who stayed in the household the night before the interviewer's visit. Eligible children, about whom questions on treatment of fever are asked, are defined as biological children of interviewed women who were born in the year of the interview or in the previous five calendar years.

XIV. REFERENCES

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