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COMPARISON OF THE COSTS AND DATA OUTPUTS OF CONVENTIONAL CLUSTER SAMPLING AND LOT QUALITY ASSURANCE SAMPLING (LQAS) FOR ASSESSING THE COVERAGE OF FORTIFIED FOODS IN HOUSEHOLD SURVEYS

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ABSTRACT

Household surveys are essential for assessing the coverage of public health programmes, including large-scale food fortification (LSFF) programmes in developing countries. For decades, survey implementers have predominantly designed and implemented household-based surveys using conventional cluster sampling, but other sampling approaches, such as lot quality assurance sampling (LQAS), should be considered as an alternative. This study compares the costs and data outputs of conventional cluster sampling and LQAS when used to measure the household-level coverage of a hypothetical LSFF programme. Specifically, four survey scenarios were compared using hypothetical results: conventional cluster sampling to calculate the coverage of fortified foods at the national (scenario A) and regional (scenario B) levels, and LQAS to produce pass/fail results at the national (scenario C) and regional (scenario D) levels. For each scenario, sample sizes were calculated using a target coverage of 25%, 50%, and 75%, and used previous surveys to estimate survey budget costs, which consisted of the costs of administration, field workers, other personnel, materials, and laboratory testing. A national level LQAS survey (scenario C) had the lowest estimated costs (69,424 – 73,462 USD), followed by a national level conventional cluster sampling survey (scenario A) (82,620 – 90,164 USD). There were higher overall costs and larger cost differences between sampling approaches for surveys designed to yield regional estimates. Here, costs for a conventional cluster sampling survey (scenario B; 212,210 – 251,470 USD) are more than double those for a LQAS survey (scenario D) (113,060 – 129,540 USD). Sample size is the main driver of survey costs in all scenarios, while costs for field teams (salaries and transportation) and laboratory analyses of food samples vary depending on the scenario and coverage threshold; all other survey costs (e.g., ethical approval, training & field testing) remain relatively stable across different scenarios and thresholds. While LQAS surveys can be implemented at a lower cost due to smaller sample size requirements, the cost savings are less than expected due to the more dispersed distribution of households. Furthermore, because LQAS are initially designed to yield only pass/fail classification rather than estimates of actual coverage, they may not provide the actionable insights required in routine programme monitoring. When selecting a survey sampling approach, food fortification programme planners must consider what type of results best suit their decision-making needs and available resources.

Key words: Coverage, Food Fortification, Sampling, Lot-Quality Assurance Sampling, Cluster-sampling

INTRODUCTION

Large-scale food fortification (LSFF) is one of the most efficacious and cost-efficient interventions to sustainably prevent and ameliorate deficiencies in iron, vitamin A, iodine, zinc, and other micronutrients [1]. This is especially important for people whose diets consist primarily of refined grains or foods with low levels of micronutrients. There are LSFF programmes implemented in many countries, and, as of 2020, the fortification of maize flour, wheat flour, rice, salt, and vegetable oil is mandatory in 17, 85, 7, 123, and 17 countries, respectively [2]. In sub-Saharan Africa, the number of countries implementing LSFF programmes has steadily increased since the 1990s and early 2000s and as of October 2020, 10 out of the 46 countries in sub-Saharan Africa have mandatory fortification in place for maize flour, 20 for vegetable oil, 44 for salt, and 26 for wheat flour [2]. Additionally, the West African initiative Faire Tache d'Huile has harmonized the vegetable oil fortification standards across 15 countries [3].

To track the overall performance of LSFF programmes, monitoring systems are routinely established [4] which typically assess various components of a fortification programme, such as premix procurement and use [5], production and quality control, marketing and communications, household coverage, and health impact. Programme planners can more easily identify and address discrete implementation challenges by monitoring LSFF programs at multiple levels. Once "up-stream" milestones in the monitoring plan have been met, a household-based survey to measure the household coverage of a LSFF programme should theoretically be implemented. These "up-stream" milestones could include evidence that micronutrient premix is being consistently added to staple foods and that a minimum proportion of a food staple produced in a country or region is being fortified.

Despite detailed monitoring systems, successful implementation of LSFF programmes has proven difficult, especially in low-resource settings, where some programs have demonstrated low coverage and failed to demonstrate potential for impact [6,7]. Poor programme performance can be attributed to a variety of factors, but is frequently the result of programme design and implementation failures, such as the failure to conduct routine monitoring activities [7]. Conventional cluster sampling approaches are commonly used in household surveys to provide representative point estimates of the coverage of an intervention in the population. For example, Fortification Assessment Coverage Toolkit (FACT) surveys typically employ a multi-stage cluster sampling approach to provide estimates of household-level coverage of fortified foods. In the first stage of sampling, FACT surveys select

clusters, which are typically based on census enumeration areas or demarcated villages, using random sampling, often with probability proportional to size (PPS). In the second stage, households are selected using random sampling from within the sampled clusters, and in the third stage target individuals are selected within the sampled households, if necessary [8]. While such sampling approaches, when done correctly, provide representative coverage estimates, they generally require large sample sizes, which often require substantial financial, personnel, and equipment and supplies resources to collect and analyse the data.

Surveys designed using lot quality assurance sampling (LQAS) techniques may be a less-costly alternative for assessing household coverage of fortified foods compared to those designed using conventional cluster sampling approaches. LQAS was developed and initially used as a quality control tool for the manufacturing of goods and products. Over the last three decades, this technique has been adapted to assess the performance of public health programmes [9]. The LQAS approach was designed for binary classification of compliance, enabling researchers and programme managers to determine if a predefined threshold, such as a coverage target has or has not been achieved. As a result, it requires a smaller sample size than conventional cluster sampling and can be implemented with relatively few resources [10].

In this study, we estimate the costs of conducting a household-based survey to assess the household coverage of fortified foods designed using both conventional cluster sampling and LQAS approaches in a fictitious country on the national and sub-national level. Costs and data outputs from both approaches are then compared, and the benefits and limitations of each sampling approach are discussed.

MATERIALS AND METHODS

Methodology definitions and terminologies

Due to the difference in sampling designs, the terminology used by conventional cluster sampling and LQAS are not directly comparable. Nonetheless, a comparison of the sampling approaches is given here to improve the reader's understanding of the two sampling strategies as applied to household-based surveys. Using conventional cluster sampling for a nationwide assessment of fortification coverage, a sampling universe typically includes the entire country unless access is limited by insecurity or other factors. Subsequently, the number of strata for which individual separate estimates are desired is determined, and then the primary sampling units (PSU) from within each stratum are selected. The group

of households selected from within each selected PSU is referred to as a cluster. The number of PSUs to be selected within each stratum and the number of households to be selected from each PSU is determined from a combination of required statistical precision and available resources. For LQAS, the catchment area (CA) is the largest level of analysis for which results are generated. Within a CA, supervision areas (SA) are selected, and households are selected from within each SA. The CA and SA can be equated to the sampling universe and stratum, respectively, in conventional cluster sampling. As the standard LQAS approach does not contain clusters, there is no direct comparison that can be made.

Sampling universe, sampling frame and survey scenarios

For both sampling approaches the sampling universe consisted of all households residing in the fictitious country. Sample sizes and cost estimates were made for four separate scenarios based on stratification commonly-used by the two sampling methods. For these scenarios, our hypothetical country was divided into 10 strata/ SAs, each of the strata serving as its own sampling universe. The number of 10 strata/SAs was chosen since with this stratification for most LSFF programmes, sufficiently detailed information were obtained to draw programme decisions and 10 SAs are still reasonable in terms of survey costs and complexity. For this method comparison, we left the nature of strata/SAs undetermined; those could however be administrative regions, agro-ecological zones, or any other distinct LSFF specific divisions. For convenience, we will refer to them as regions. Furthermore, as LSFF programmes are almost always implemented at the national level, we assumed relatively homogenous exposure to fortified foods throughout the country.

For conventional cluster sampling, the scenarios were developed to estimate the coverage of fortified foods only at the national (scenario A) and for each region separately (scenario B). For LQAS, the scenarios were developed to produce pass/fail results at the national level only (scenario C) and regional levels (scenario D) (Table 1).

Conventional cluster sampling, as described elsewhere [11,12], was done in accordance with standard sampling procedures. The simulation assumes two-stage sampling. The sampling frame for the 1st stage of sampling is a list of primary sampling units, such as census enumeration areas, including all households residing in the country. The first sampling stage consists of the selection of PSUs with PPS (probability proportional to size) sampling. The sampling frame for the 2nd stage of sampling is a list of all households residing in the selected PSUs and the 2nd sampling stage consists of selection of households within selected PSUs with

equal probability. The simulation for LQAS assumes simple random sampling (one-stage sampling) as the standard LQAS approach does not use PSUs/ clusters. The sampling frame is a list of all households residing in the country or region and the selection of households is done with equal probability.

Sample size calculation using conventional cluster sampling

Table 2 shows the calculation of the minimum number of households from which data must be collected to meet the pre-determined precision requirements. The sample size required for each stratum was based on the assumed coverage, the desired precision around the resulting coverage estimate, and the expected design effect. Assumed or target coverage was set to 25%, 50% and 75%, and three separate sample sizes were calculated for scenarios A (national) and scenario B (regional). A design effect of 2.5 and a precision of ± 10 percentage points were used to determine sample size, since this is in the range of design effects applied for fortified foods coverage assessments in national surveys [8,13,14]. Calculations assumed an expected household response rate of 90%. All calculations used Fisher's formula to calculate the minimum sample size to meet the precision requirements:

Fisher's formula

$$n = \frac{Z_{\alpha/2}^2 P(1 - P)}{d^2} \times DEFF \times \frac{100}{RR} \quad (1)$$

Where:

$Z_{\alpha/2}$ = Z-value corresponding to the 1- α confidence level (usually 95% confidence intervals, so $Z_{\alpha/2} = 1.96$)

P = Assumed coverage

d = Desired precision expressed as half of a confidence interval in decimal form

DEFF = Design effect

RR = Household response rate expressed as a percentage

For conventional cluster sampling, the number of households to select from each cluster is a key decision that will affect the number of clusters selected. Although the number of households selected from each cluster can vary and is arbitrary, 10 households per cluster shall be used for this comparison in order to not inflate the design effect and ensure that there are sufficient numbers of clusters in each stratum.

Sample size calculation using LQAS sampling

Table 3 shows the sample sizes that were calculated to assess whether coverage was below or above certain targets for scenario C (national) or scenario D (regional) using a LQAS sampling plan calculator [15]. To calculate sample sizes (n) using the LQAS sampling calculator, upper and lower thresholds were established first. To make an approximate comparison to the coverage estimates for conventional cluster sampling, the LQAS coverage targets (p_a) — or upper thresholds were set to 25%, 50%, and 75%. The respective lower thresholds (p_o) were set at 10%, 25%, and 50%. These thresholds, although arbitrary, approximately simulate that of poor-, moderate-, and high-performing fortification programmes. Only salt iodization has internationally-stipulated recommendations for coverage, and a household coverage of 90% is considered “universal” [16]. As global salt iodization is more advanced than the fortification of other food vehicles, an upper threshold of 75% was deemed appropriate. To calculate the sample sizes for the various threshold pairs, the probability of having a type I error or type 2 error (also known as a “false positive” or “false negative”, respectively) were both set to $\leq 5\%$. Following this, the number of households to select per SA (n) and the decision rule (pass/fail) (d) for each SA were calculated to ensure that the risk of false positives or false negatives were below or equal to the predetermined levels [15]. The decision rule (d) is a predetermined cut-off above which the number of successes in area SA result in the SA being classified as a “pass”. In our case, “successes” equates to the number of households consuming fortified foods. The determination of the cut-off, d, is a function of the sample size, coverage targets and acceptable classification error; as such, d was calculated for each target threshold separately. Equations 2 and 3 [17] are used in concert to calculate n and d, which are then used to calculate the sample sizes for LQAS:

n = number of households to select per SA

d = decision rule, if successes > d, then the SA would be classified as acceptable,
and if successes \leq d, then the SA would be classified as unacceptable

p_o = lower threshold

p_a = upper threshold

α = alpha error, or the risk of classifying a SA as false positive

β = beta error, or the risk of classifying a SA as a false negative

Equations used to calculate n and d

$$n = \left[Z_{1-\alpha} \{P_o(1-P_o)\}^{0.5} + Z_{1-\beta} \{P_a(1-P_a)\}^{0.5} \right]^2 / (P_a - P_o)^2 \quad (2)$$

$$d = \left[(nP_o) - Z_{1-\alpha} \{nP_o(1-P_o)\}^{0.5} \right] \quad (3)$$

Budget estimations

Overall budget estimates were based on administrative costs (including training venue rental, ethical approval, and cluster maps), field worker costs (per diems and transport) for training, pre-testing and field work, survey manager and trainer costs (protocol development, training, supervision, and data analyses), survey material costs (stationary, tablet computers, and backpacks) and laboratory costs. Most fortification coverage surveys involve the collection of household food samples, such as salt, wheat flour, or edible oil, for quantitative measurement of fortificants in a laboratory. Cost per item has been estimated using the authors' experience in implementing surveys in a variety of countries in sub-Saharan Africa. For both conventional cluster sampling and LQAS, the same per item costs were used to allow for comparability.

RESULTS AND DISCUSSION

Aaron *et al.* [7] compared the coverage results from 18 LSFF programmes implemented in eight countries and found that none of the programmes implemented in Nigeria, Senegal, Tanzania, Uganda, Bangladesh, and India met the authors' three predefined performance targets. The authors found that in four programmes, a large proportion of the food vehicle was not fortified, and for six programmes, the food vehicle was not fortifiable, where fortifiable was defined as a food vehicle that was "processed industrially and hence [was] well suited to large-scale fortification" [7]. These findings highlight the heterogeneity of programme performance and show that information about the coverage of fortified foods in the population is essential for understanding LSFF programme performance and identifying areas for improvement. To constantly monitor the performance of fortification programs, approaches that are less costly and less complex than conventional cluster sampling are warranted. The World Health Organization (WHO) developed the Expanded Programme on Immunization (EPI) 30 cluster survey method to assess the coverage of vaccination programmes. Similar to conventional cluster sampling, the EPI 30 cluster survey method uses a 2-stage sampling approach, but selects a fixed number of clusters (30) and data points within the cluster [11]. The method was not further investigated as part of this work though it is less complex compared to conventional cluster sampling since it does not account for factors impacting sample size such as the expected coverage or the desired precision. Further, no substantial cost savings could be expected since, in certain circumstances, smaller sample sizes than the 30 EAs per strata would be sufficient to estimate coverage. In contrast, we were able to identify LQAS as a potentially cost-efficient approach, which has the potential to replace

conventional cluster sampling, depending on the information sought by the programme planners.

Comparison of sample sizes and costs

This analysis provides a practical comparison of the costs and level of results for hypothetical household surveys assessing the coverage of fortified foods designed using conventional cluster sampling and LQAS.

When calculating the sample sizes using the conventional cluster sampling for a national prevalence estimate (scenario A), an assumed coverage of 25% resulted in a sample size of approximately 200 households. Distributing these households into clusters with 10 households, each would require the selection of 20 clusters in the first stage of sampling. The same minimum sample size applies to an estimated coverage of 75% for scenario A. For an estimated coverage of 50% in scenario A, the minimum sample size is approximately 270 households distributed into 27 clusters of 10 households each. For the stratum specific estimates (scenario B, 10 strata), an estimated coverage of 25% or 75% resulted in a survey sample of approximately 2,000 households spread across 200 clusters. When the estimated coverage was 50%, approximately 2,700 households was distributed across 270 clusters.

When calculating the sample size using LQAS for scenario C, where only a pass/fail result for the entire country is required, only one SA was required for the country. Within this SA, the number of households enrolled would be based on the pre-established threshold targets (see Table 4). For scenario D, each of the 10 strata served as independent SAs and the country served as the CA.

Survey costs range from approximately 70,000 to 250,000 USD depending on the sampling methodology, level of analyses, and sample size. The sample size substantially influences the costs of salaries and transport of field teams and laboratory analyses. The LQAS required higher per household costs because the dwellings of selected households in a LQAS survey were more dispersed. As a result, the difference in total cost between conventional cluster surveys and LQAS surveys was smaller than expected when looking only at sample size.

As shown in scenario C of Table 5, a national survey using LQAS, has the lowest cost, ranging from 69,424 – 73,462 USD. Scenario A, a national-level survey using conventional cluster sampling was only slightly more costly (82,620 – 90,164 USD). Large cost differences were calculated for conventional and LQAS if surveys were designed to yield regional estimates. Here, costs for conducting a survey

using conventional cluster sampling (Scenario B; 212,210 – 251,470 USD) was more than double compared to a LQAS survey (Scenario D; 113,060 – 129,540 USD).

Surveys designed using LQAS methods required a smaller sample size and can be implemented at lower costs compared to those designed using conventional cluster sampling approaches. However, the cost savings are smaller than expected due to the more dispersed distribution of households by LQAS. Since the results produced by each sampling approach differ, the lower costs of an LQAS survey are only advantageous when “pass/fail” classifications are sufficient to make programmatic decisions. While Scenario C (National LQAS) had the lowest budget, there could be challenges to implementing LQAS surveys as they would require a complete list of households for an entire country. Though it is possible to obtain such lists from the previous census through national statistical offices, those lists might not be up-to-date. Selecting households from those lists might therefore introduce a selection bias as not every household is listed and thus not every household has the same probability of being selected. If a country had an up-to-date census, this scenario could be readily implemented. Alternatively, census enumeration areas could be selected from each SA with simple random sampling proportional to the SA’s share of the total population, and households from each enumeration area listed before simple random selection of the households. However, as scenario C would not provide any sub-national information, this scenario could potentially best be used to compliment other surveys that provide more sub-national information.

To our knowledge, this is the first study to compare the costs of conventional cluster sampling and LQAS when used to measure the coverage of LSFF programmes. This study, however, is not the first to compare survey costs between a conventional cluster sampling and LQAS design. Valadez and Devkota [18] compared costs from a cluster randomized baseline survey to a follow-up survey using LQAS sampling to collect data for a community health programme in Nepal. They estimated that costs for conducting an LQAS survey were half of the costs required for a cluster survey. Similarly, Anoke *et al.* [19] compared costs between a Demographic Health Survey using conventional cluster sampling and a LQAS survey in one region of Uganda. These studies found that costs for the surveys using conventional sampling were about 2-4 times higher in Nepal and Uganda, respectively, compared to the LQAS surveys. Cost differences between the surveys mainly emerged since the LQAS surveys used field workers who were already employed by the programme, which resulted in considerable savings in salary, transport, and accommodation costs. As LSFF programmes are typically

implemented at the national level and do not have regional or community level staffers dispersed across a country, these types of cost savings could only occur if a LSFF programme were able to utilize the personnel from another public health programme. Moreover, field workers who are dispersed throughout the country and whose salaries are covered could be used by a LSFF programme to implement either a LQAS survey or survey using conventional cluster sampling. As such, any cost savings by using field workers identified by other comparisons of LQAS and conventional cluster sampling surveys would not directly apply to survey implemented by a LSFF programme.

From a logistical and monetary perspective, the selection of multiple households from a single PSU, which typically encompasses a small geographic area, is advantageous. In contrast to conventional cluster sampling, the households in LQAS surveys are widely dispersed within a SA, resulting in slightly higher transport costs. Under Scenario C, for example, household would be selected from a list of households or census of the entire country. As these households could be highly dispersed, substantial transport costs would be required despite the relatively small sample size. The budget comparisons for this study assumed that public transport would be used by teams implementing both a conventional cluster sampling survey and an LQAS survey. Though differing transport solutions could be envisioned for each scenario, utilizing the same transport option for all scenarios enables a more apt comparison. To resolve logistical challenges due to the dispersion of households, several methods have been proposed on how the LQAS design can be adjusted in order to accommodate a cluster design [10,20,21]. Large country LQAS (LC-LQAS) surveys already integrate LQAS and cluster sampling and provide prevalence estimates at the regional level and pass/fail classification for the next smaller administrative unit (enumeration area) [22,23],) and are therefore not directly comparable to standard LQAS surveys.

Although LQAS was developed to yield pass/fail results, it might alternatively be used to produce prevalence estimates for the entire project area by aggregating the SA level data [19,23]. Anoke *et al.* [19] compared the prevalence estimates between two surveys conducted in the same region of Uganda using both LQAS and conventional cluster sampling: More than three quarters of the investigated indicators showed good agreement. In our example, results from scenario D (pass/fail results at the regional level) can be aggregated to produce a national prevalence estimate, similar to scenario A (conventional cluster sampling at the national level). To produce a national prevalence estimate with this approach, the crude prevalence of each SA would need to be calculated and weighted for the population sizes of the SAs, and then aggregated for the CA.

While the cost of scenario D is considerably higher than Scenario A, scenario D provides programme managers with additional data (pass/fail results at the regional level) and thus could be considered advantageous. To illustrate, pass/fail results at the regional level could be used to determine the performance of regional food producers, such as wheat flour mills, to implement a national fortification programme. Moreover, in contrast to conventional cluster sampling, no design effect would have to be applied for the LQAS results since samples are collected using simple or systematic random sampling without intra-cluster correlation [18].

The cost of implementing the technical aspects of LQAS and conventional cluster sampling surveys, such as protocol development, sample size calculation, data analysis, and reporting, is essentially the same. The requirements for data analysis are similar, necessitating similar levels of technical expertise.

Considerations for programme planners

When evaluating the performance of LSFF programmes, multiple coverage indicators were assessed. Commonly-examined indicators included the coverage of the food vehicle, coverage of the food vehicle that is fortifiable and produced by large-scale food producers, coverage of the fortified foods vehicle (with vitamins and/or minerals added in any amount), and coverage of the adequately fortified food vehicle (with vitamins and/or minerals added in accordance with national standards) [7]. Thus, prior to implementing a coverage survey, programme planners must clearly define what coverage indicators will be assessed since a) the various coverage indicators have different target coverages which impacts the sample size, and b) the choice of the indicator might impact the decision about which sample design to use, as some indicators might require point estimates whereas for others a pass/fail result indicating if a coverage threshold has been met may suffice.

Furthermore, programme planners must determine what type of coverage survey will produce the most usable results based on their available budget. Prior to selecting a survey sampling methodology, many factors must be considered, including the maturity of the LSFF programme, the availability of coverage data from previous assessments, and government and donor reporting requirements. Prior to launching an LSFF programme, programme planners can conduct survey activities to gather key information required for programme design. An LSFF programme, for example, may be justified only if a sufficient proportion of households consume a fortifiable food vehicle. An LQAS survey may provide

enough information to justify (or reject) an LSFF programme implementation or it may help determine the geographic scope of a LSFF programme's implementation.

A regional LQAS survey (Scenario D) may also be useful in the early stages of programme implementation by identifying regions that have met (or have not met) a specific coverage threshold. During the early stages of an LSFF programme, the LQAS approach may be a more cost-effective method of identifying regions that are experiencing implementation challenges. Importantly, LQAS should not be used if the expected coverage is less than 10% [24].

Stratum-specific pass/fail results may also be useful to LSFF programme managers in large countries in which multiple producers of a fortified food vehicle, such as wheat flour, are operating in different regions of the country. Results from an LQAS survey could help determine areas where the LSFF is performing well or facing challenges. This same programmatic question could be answered using conventional cluster sampling at the regional level (Scenario B), but the cost of this type of survey would be considerably higher than LQAS. Another advantage of LQAS, which must be taken into consideration when deciding on the sampling approach, is that regional pass/fail estimates can be aggregated to a national prevalence estimate, thereby providing a point estimate of the national coverage [19].

Conventional cluster sampling would be preferred over LQAS in situations where programme planners want to track trends in the coverage of their LSFF programme. Conventional cluster sampling surveys may also be preferred if programme planners want to measure small changes in programme coverage or if researchers want to investigate the relationships between LSFF programme performance and individuals' micronutrient status.

Limitations

This study compares various survey types in a fictitious country. While the assumptions used are based on the authors' experience across many countries, actual costs and requirements may vary significantly in different contexts. It is recommended that a survey using these sampling approaches be conducted so that actual expenditures and results can be compared.

CONCLUSION

This study found that the cost of a survey designed using LQAS is lower than with conventional cluster sampling approaches. The cost savings for national-level



surveys are modest, whereas stratified LQAS surveys can be considerably less costly than stratified surveys using conventional cluster sampling. Surveys designed using LQAS yield “pass/fail” results, which would not be suitable for situations where programme managers require national and/or stratum-specific prevalence coverage estimates to make programmatic decisions. When designing household surveys for assessing LSFF programme coverage, survey designers and programme planners must consider trade-offs in different sampling methods and choose the method that yields results that best suit their programmatic and decision-making needs as well as available resources. It is recommended that programme planners first determine the information that is required from a LSFF coverage survey prior to designing the survey and selecting a sampling strategy.

Funding:

This work was supported, in whole or in part, by the Bill & Melinda Gates Foundation [OPP1156469]. Under the grant conditions of the Foundation, a Creative Commons Attribution 4.0 Generic License has already been assigned to the Author Accepted Manuscript version that might arise from this submission. The Bill & Melinda Gates Foundation as the funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Bradley A. Woodruff (B.A.W) for his comments on the initial draft of this manuscript.

Contributors: Conceptualization: V.M.F., M.N.N.M, N.P., J.P.W.; Formal analysis: N.P.; Funding acquisition: V.M.F., M.N.N.M.; Methodology: J.P.W., N.P.; Project administration: V.M.F., M.N.N.M.; Writing–original draft: J.P.W., N.P., B.A.W.; Reviewing and providing input to manuscript draft: J.P.W., N.P., V.M.F., M.N.N.M., B.A.W., FR.

Declaration of interest: The authors declare no competing interests. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions, policy or views of the Global Alliance for Improved Nutrition.

Table 1: Conventional cluster sampling and LQAS scenarios

Level of survey results	Type of results produced	Conventional cluster sampling	LQAS
National	Pass/Fail		C
	Point estimate	A	*
Sub-national	Pass/Fail		D
	Point estimate	B	

*The results from scenario D, which is designed to produce stratum-specific pass/fail results, can be aggregated to estimate a national point estimate

Table 2: Sample size calculation for conventional cluster sampling

Coverage levels	Estimated coverage	Desired precision (percentage points)	Assumed design effect	Assumed Household Response	Number of households in one stratum (Scenario A)	Number of households in all ten strata (Scenario B)
1	25%	±10	2.5	90%	201	2,010
2	50%	±10	2.5	90%	267	2,670
3	75%	±10	2.5	90%	201	2,010



Table 3: Coverage thresholds, α and β errors, and number of households and decision rule per supervision area (SA) [15]

Coverage levels	Lower threshold	Upper threshold (target coverage)	Alpha error	Beta error	d (decision rule)	n (number of households per SA)*
1	10%	25%	$\leq 5\%$	$\leq 5\%$	12	70
2	25%	50%	$\leq 5\%$	$\leq 5\%$	16	42
3	50%	75%	$\leq 5\%$	$\leq 5\%$	27	42

*To account for household absence and refusal, additional households should be randomly selected prior to the start of the fieldwork, with 64 or 39 households completed per SA

Table 4: Number of CAs, SAs and households for different scenarios

Scenarios		Number of CAs	Number of SAs per CA	Number of households per SA	Total number of households
C	National pass/fail; 10%, 25%	1	1	70	70
	National pass/fail; 25%, 50%	1	1	42	42
	National pass/fail; 50%, 75%	1	1	42	42
D	Regional pass/fail; 10%, 25%	1	10	70	700
	Regional pass/fail; 25%, 50%	1	10	42	420
	Regional pass/fail; 50%, 75%	1	10	42	420

CA, catchment area; SA, supervision area

Table 5: Estimated survey costs for various sampling scenarios and coverage estimates or thresholds

	Scenario A - Conventional Cluster Sampling (National)			Scenario B - Conventional Cluster Sampling (Regional)			Scenario C - LQAS (National)			Scenario D - LQAS (Regional)		
	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
<i>Number of field manager</i>	2	3	2	5	5	5	2	2	2	2	2	2
<i>Number of teams</i>	2	3	2	15	15	15	10	10	10	20	10	10
<i>Team members/ team</i>	2	2	2	2	2	2	1	1	1	1	1	1
<i>Number of field working days</i>	20	18	20	27	36	27	9	6	6	20	25	25
Ethical Approval, cluster drawings, Training, and Pre-testing	3,900	4,500	3,900	22,930	24,330	22,930	6,900	6,900	6,900	10,800	6,900	6,900
Field Team Costs	8,640	11,664	8,640	60,480	80,640	60,480	6,660	4,440	4,440	28,400	19,750	19,750
Survey team transport Costs	10,000	13,500	10,000	40,500	54,000	40,500	4,950	3,300	3,300	16,000	13,750	13,750
Laboratory costs	1,200	1,620	1,200	12,000	16,200	12,000	432	264	264	4,320	2,640	2,640
Personnel costs	58,880	58,880	58,880	76,300	76,300	76,300	54,520	54,520	54,520	70,020	70,020	70,020
Total costs	82,620	90,164	82,620	212,210	251,470	212,210	73,462	69,424	69,424	129,540	113,060	113,060



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