

Description and comparison of the methods of cluster sampling and lot quality assurance sampling to assess immunization coverage

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Abbreviations

EPI	Expanded Programme on Immunization
LQAS	lot quality assessment sampling
PPS	probability proportionate to the size
SRS	stratified random sample
WHO	World Health Organization

1. Introduction

The cluster survey used to assess coverage of immunization systems (30 by 7 cluster) and Lot Quality Assessment Sampling (LQAS) are two of the more highly used sampling methods to assess immunization coverage. The 30 by 7 cluster survey is a modified two-stage cluster sample and the LQAS method is a type of stratified sample. Both of these sampling techniques can be used to obtain overall population estimates of immunization coverage. This report provides a brief description of these two sampling methods, describes the general aspects of cluster and stratified sampling designs, compares and contrasts the two methods, and provides guidelines for immunization system staff on the setting in which each is appropriate.

2. Brief description of the 30 by 7 cluster sample used to assess immunization coverage

The 30 by 7 cluster sample was developed by WHO in 1978. The goal of this sampling design was to estimate immunization coverage to within ± 10 percentage points of the true proportion, with 95% confidence. The 30 by 7 cluster survey is a two-stage cluster sample. Before the sampling begins, the population needs to be divided into a complete set of non-overlapping subpopulations, usually defined by geographic or political boundaries. These subpopulations are called *clusters*. In the first stage, 30 of these clusters are sampled with probability proportionate to the size (PPS) of the population in the cluster. Sampling with probability proportionate to size allows the larger clusters to have a greater chance of being selected. The clusters are sampled with replacement, such that each cluster can be included in the sample more than once. In the second stage of sampling, seven subjects are selected within each cluster. Although the sampling unit is the individual subject, the sampling is conducted on the household level. The subjects are chosen by selecting a household and every eligible subject in the household is included in the sample. With traditional PPS cluster sampling, each of the seven subjects would be randomly selected. With the 30 by 7 method, however, only the first household is randomly selected (by a variety of different methods), and all eligible subjects in that household are sampled. After the first household is visited, the surveyor moves to the “next” household, which is defined as the one whose front door is closest to the one just visited. This process continues until all seven eligible subjects are found. Not all of the first seven households visited will necessarily have an eligible subject, therefore more than seven households may have to be visited. Also less than seven households may need to be selected if there is more than one eligible subject per household. The information from each cluster is then combined to obtain an overall estimate of immunization coverage. A step-by-step guide for conducting an immunization coverage survey is provided in the WHO document *Training for mid-level managers: the EPI coverage survey WHO/EPI/MLM/91.10*.

3. Brief description of the generic cluster sample

In a cluster sample, the population is divided into non-overlapping subpopulations usually based on geographic or political boundaries. For a simple cluster sample, a random sample of subpopulations (clusters) is obtained and, within each selected cluster, each subject is sampled. More often, a two-stage cluster sample design is used where a random sample of clusters is selected and, within each cluster, a random sample of subjects. The two-stage design can be expanded into a multi-stage one, in which samples of clusters are selected within previously selected clusters. A benefit of this type of cluster sample is that a list of the units in the population is only needed for those clusters that are selected.

A common modification to the cluster sample design is to select the clusters with probability proportionate to the size of some variable in the population, such as the population size (as in the 30 by 7 cluster sample), the number of health facilities in the region, or the number of immunizations given in a week. This type of cluster sample is said to be *self-weighting* because every unit in the population has the same chance of being selected.

In theory, clusters are chosen to be as heterogeneous as possible, that is, the subjects within each cluster are diverse and each cluster is somewhat representative of the population as a whole. Thus, only a sample of the clusters needs to be taken to capture all the variability in the population. In practice, however, clusters are often defined based on geographic regions or political boundaries, so that conducting a cluster sample reduces the time and cost associated with the survey. In this situation, the elements within the clusters may be rather homogeneous and, on average, the clusters may be very different from one another. Because of this, for a fixed sample size, the variance from a cluster sample is usually larger than that from a simple random sample, and therefore the estimates are less precise.

Some main advantages and disadvantages of a general cluster sample are as follows.

Advantages:

- Only need to obtain list of units in the selected clusters.
- Cost-effective.

Disadvantages:

- Not intended for calculation of estimates from individual clusters.
- Less precise than simple random sample.

Differences between the 30 by 7 cluster sample and the generic cluster sample

The main difference between the 30 by 7 cluster sample and the generic two-stage cluster sample is that in the 30 by 7 cluster sample only the first household in each cluster is randomly selected. Another issue with the 30 by 7 cluster sample is that every eligible individual in the household is included in the sample. These two modifications can lead to some biases.

If the immunization coverage is concentrated in specific areas of the cluster, this “pocketing” may lead to a biased estimate. The level of immunization coverage could be overestimated if the first household selected is located in a “pocket” of immunization, or it could be underestimated if the first household is located outside of the “pocket”. Simulation studies have been conducted to assess the bias that may be introduced into the estimate by the fact that only the first household is randomly selected. It was concluded that in most cases the bias is small because the number of clusters is relatively large. Results from these studies also reinforce the notion that estimates should not be obtained for individual clusters. The potential for bias could be eliminated by randomly selecting all of the households. To do this, however, a list of all households in the selected clusters would need to be obtained, which may add a considerable amount of time and effort to the implementation of this sample. There are additional modifications that could also be introduced to decrease the chance of bias. Some examples include, selecting every k th household, or stratifying each of the selected clusters into regions and choosing part of the sample from each of the regions. All of these methods may also increase considerably the time needed to perform the sampling.

In the 30 by 7 cluster sample, once a household is selected, every eligible individual in the household is selected. Because of this, not all of the 210 subjects in the sample are independent. This may introduce bias into the estimate because subjects in the same household tend to be homogeneous with respect to immunization. For example, if women with many children are less likely to get their children immunized the immunization coverage may be underestimated. This bias could be alleviated by randomly selecting one child per household. Although it would be easy to select randomly one child per household, it would possibly increase the number of households that need to be visited to obtain the seven subjects per cluster.

The sample size for the 30 by 7 cluster sample is set at 210, which provides an estimate that should fall within 10 percentage points of the true population percentage. In most situations this is adequate, however, when immunization coverage is extremely high (e.g. only 1 person in 1000 is not immunized), estimating this proportion to within 10 percentage points is not very informative. Because of this, it may be necessary to increase the sample size. This could be done by increasing both the number of clusters and the sample size per cluster, or by just increasing the sample size in each of the 30 clusters. More extensive sample size calculations would be needed to obtain the optimal combination of clusters and samples per cluster for each situation.

4. Brief description of lot quality assurance sampling

Lot quality assurance sampling (LQAS) originated in the manufacturing industry for quality control purposes. Manufacturers were interested in determining whether a batch, or lot, of goods met the desired specifications. Rather than checking each item in the lot to determine the number of “defects”, they decided to take a sample of the items and define the level of risks they were willing to take for not inspecting each and every item. Based on these risks, they would decide to accept, or reject, the entire lot. The only outcome in this type of sampling is “acceptable” or “not acceptable”. There is no measure as to different levels of unacceptability. For example, one lot may be deemed unacceptable because of two defective items out of 10 sampled, and another lot with all 10 defective items will be assigned the same classification of unacceptable.

The sample size and decision values for lot quality assurance sampling are based on the risks that the investigators are willing to take. The sample size is the number of units that are selected from each lot. The decision value is the number of “defective” items that need to be found before the lot is deemed unacceptable. There are two types of risk that need to be considered: (i) the risk of accepting a “bad” lot, referred to as Type I Error, and (ii) the risk of not accepting a “good” lot, referred to as Type II Error. Based on the risks and the hypothesized proportion of defects in the lot, the sample size and decision value can be obtained.

Although it is not the original intention of the LQAS method, information from lots can be combined to obtain the overall proportion of defects. To do this, the population is first divided into a complete set of non-overlapping lots. Samples are then taken from every lot, and the proportion of defective items in each lot is calculated. The overall proportion of defects in the population is estimated by taking a weighted average of the estimated proportion of defects from each of the lots. A corresponding confidence interval can be calculated as well. Since the overall proportion of defects is determined by combining the information from each of the lots, the LQAS method is an example of stratified sampling, where the lots play the role of the strata. The advantage of the LQAS method over a traditional stratified sampling design is that the response for each lot is binary (acceptable or not), and therefore smaller sample sizes can be used. For a traditional stratified sample, a confidence interval with a certain precision is usually desired for each stratum (or lot), which requires a larger sample.

A modification to the previously described LQAS method is the implementation of “double sampling”. The method is useful in some situations to decrease the sample size. With the double sampling method, a first sample of size n_1 is selected. If more than d_1 items are found to be defective, the lot is deemed to be “unacceptable”

and the sampling in the lot is over. If the number of defects is less than or equal to d_1 , another n_2 items are selected, and if more than d_2 items in the sample of n_1+n_2 items are found to be defective, the lot is deemed to be “unacceptable”. Otherwise the lot is classified as “acceptable”.

In terms of immunization assessment, “acceptability” is usually determined by whether the lot meets some desired proportion of immunization coverage. To use the LQAS method for assessing immunization coverage, some parameters need to be set before the sampling can begin. First, the level of immunization coverage that would be deemed “unacceptable” needs to be determined. Second, the level of immunization coverage that is desired needs to be defined. Third, the amount of risk you are willing to take for incorrectly judging an unacceptable lot as being acceptable. Finally, the amount of risk you are willing to accept for deeming an acceptable lot unacceptable. Usually, the risk of classifying an unacceptable lot as acceptable is set lower than the risk of classifying an acceptable lot as unacceptable because it is usually a more serious error to judge an unacceptable lot as being acceptable when it is not. The sample size and the decision value are selected so that the lots with high immunization coverage have a good chance of being classified as acceptable and those with poor immunization coverage as unacceptable. The larger the difference between the level of immunization coverage defined to be unacceptable and the desired level of immunization coverage, the smaller the sample size that is needed, and the less precise your results will be.

The LQAS method can be used by immunization system staff to determine whether their individual “lot” is acceptable or not using a relatively small sample. Because of the small sample needed for assessment of an individual lot, the assessment can be made more frequently. Although the LQAS method is not generally associated with overall population estimates, the combined samples from all of the lots can be treated as a stratified sample and the overall population proportion of immunization can then be estimated. Note that when it is of interest to obtain an overall population estimate, the entire sample needs to be selected in each lot. The sampling cannot be stopped after the decision number of non-immunized persons is reached, because the interest is in the proportion of subjects immunized, not the proportion of acceptable lots. A guide for conducting an LQAS coverage survey is presented in the WHO document *Monitoring immunization services using the lot quality technique* (WHO/VRD/TRAM/96.01).

5. Brief description of the stratified sample

For a stratified sample, the population is divided into non-overlapping subpopulations defined on the basis of some known characteristic that is believed to be related to the variable of interest. For example, the population may be stratified with respect to sex, race, geographic region, etc. Since a random sample is taken from each and every stratum, a list of every unit in the population is required. An overall population estimate can be obtained by a weighted average of the estimates from each of the strata. If the overall sample size is divided among the strata using proportional allocation, the estimates from the strata are self-weighting. One of the objectives of this type of sampling design is to obtain estimates for each of the subpopulations, or strata. Therefore, the sample size is usually chosen to be large enough such that reasonably precise estimates can be obtained for each stratum.

The strata are chosen to be homogenous, such that the elements within each stratum are similar. Therefore, it is necessary to sample subjects from each stratum to obtain an overall population estimate. Since the units within each stratum are similar, the variability within each stratum is smaller, yielding more precise estimates.

Some advantages and disadvantages of a traditional stratified random sample are as follows.

Advantages:

- Production of estimates and corresponding confidence intervals for each stratum.
- Increased precision over a SRS.

Disadvantages:

- A list of all the units within each stratum required.

Difference between LQAS and traditional stratified random sample.

The standard application of the LQAS method is to determine whether individual lots are acceptable or not. The method can be extended, however, to obtain overall population estimates. This is done by treating the lots as strata, and combining the samples from all of the lots to create a stratified sample. The main difference between the LQAS method, as used to obtain population estimates, and the traditional stratified sampling design is in the sample size. The sample size using the LQAS method is typically smaller than that of a traditional stratified sample because, for each lot or stratum, only a binary decision is made (“acceptable” or “not unacceptable”).

In the traditional stratified sample, the sample size in each stratum, or lot, is large enough to estimate the sample proportion to within some desired level of precision. Although the cost of an LQAS sample is lower because of the decreased sample size, the information gained from such a sample is limited. One of the benefits touted with the LQAS method is that the sampling can be done more frequently within each lot to assess change because of the smaller sample sizes required. The downside to this, however, is that for each lot only an acceptable/not acceptable verdict is possible. Even though a lot may have undergone significant changes, it may still be deemed unacceptable, and there is no measure of the degree of “unacceptability”.

Note that for approximately the same amount of “precision”, the LQAS method actually requires a sample size that is at least as large, if not larger, than that of a stratified random sample. This is illustrated in the following example.

Example: Assume that the hypothesized (or desired) level of immunization coverage is 80%. Using a stratified random sample, to estimate the immunization coverage in each stratum to within 10 percentage points of the true value, with 95% confidence (using a one-sided confidence interval, because the LQAS method uses a one-sided hypothesis test to calculate sample size), a sample size of 44 is required for each stratum. Alternatively, assuming the desired level of immunization to be 80% and an acceptable level of immunization coverage to be 70% (i.e. 10 percentage point away from the hypothesized value), with a probability of Type I Error set to be 5% (i.e. $\alpha=0.05$, where $\alpha=1$ -the confidence level) and a probability of Type II Error set to be 0.10, a sample size of 156 subjects per lot is required. As the probability of Type II Error is increased (i.e. we allow a greater chance that an “acceptable” lot will be deemed “unacceptable”), the sample size decreases. For example, if the probability of Type II Error is increased to 20%, a sample size of 109 per lot is required, and if the probability of Type II Error is increased to 50%, a sample size of 44 per lot is required (which is the same sample size for the stratified sample).

This example highlights the inherent differences between a stratified random sample and the LQAS method. The objective of a stratified random sample is to estimate the immunization coverage with a certain precision, and the intended use of the LQAS method is to uncover the “lots” with inadequate immunization coverage. We may be less strict on what is deemed “acceptable” immunization coverage (i.e. less precise), which would lead to a smaller sample size using the LQAS method.

6. 30 by 7 cluster sample versus the LQAS

Table 1 provides a comparison of the 30 by 7 cluster sample and the LQAS method (as used to obtain an overall population estimate) with respect to key sampling issues. The main difference between the two sampling techniques is that one is a two-stage cluster sample and the other a stratified random sample. The main implication of this is that estimates for individual clusters cannot be calculated in the 30 by 7 cluster sample. The only appropriate estimate is for the population as a whole. Alternatively, while decisions can be made for each lot in an LQAS sample, these decisions are limited to “acceptable” or “not acceptable”. In general, the goal of the 30 by 7 cluster sample is to estimate the population proportion to within a certain level of precision, whereas in the basic LQAS method the objective is to test the hypothesis that the lot is unacceptable. However, both methods can be used to obtain an overall population estimate. The 30 by 7 cluster sample does not require a random sample from all of the clusters, which makes the method easier to use and more economical, but since only a single random household is selected in each cluster, this method also has a greater chance for bias (although computer simulations have shown that the bias is small). If the LQAS method is used to obtain an overall population estimate, it requires a smaller sample size than a traditional stratified sample, but it may require a much larger sample size than the 30 by 7 cluster sample. Note that the LQAS method was not originally conceived to obtain an overall population estimate, but to determine whether individual lots are acceptable or not.

The 30 by 7 cluster sample and LQAS sampling methods will be further compared using the following example.

Example: A country is divided into 200 non-overlapping districts. The main objective of the survey is to obtain the proportion of immunized children between the ages of 1–12.

To use the 30 by 7 cluster sample, the population size in each of the 200 districts is obtained. From this information, 30 districts are selected with probability proportionate to size. In each of the 30 clusters selected, seven households are selected yielding a sample size of 210 children. From the sample information, the overall proportion of immunized children can be calculated.

To use the LQAS method, the unacceptable and desirable proportions of immunization coverage, as well as the risks, need to be defined. Assume that the level of unacceptable immunization is 0.30, and the level of desired immunization coverage is 0.80. Set the risk of accepting a lot with immunization coverage of less than 30% to be 0.05, and the risk of not accepting a lot with immunization coverage greater than 80% at 0.10. Using these values, the LQAS method indicates that

seven children in each district be randomly selected and, if more than two children in each district are not immunized, the district is deemed to have unacceptable immunization coverage. Each district can be categorized as “acceptable” or “not acceptable”. Although the primary objective of an LQAS sample is to determine whether each lot is acceptable or not, the proportion of immunized children in each district can be combined to calculate the overall proportion of immunized children in the population. With this sampling method, to determine whether a district has acceptable immunization coverage or not, only seven children need to be sampled, however, to calculate the overall proportion of immunized children, a total of 1400 children must be sampled.

This example begs the question of which is the better sampling method for this scenario. The following questions help to provide guidelines on when to use each sampling method.

Questions

1) *Is it of interest to make inference about each individual subpopulation?*

If the answer is yes, then the LQAS method will need to be used because making inference about the individual clusters in the 30 by 7 cluster sample is not appropriate and can be very misleading. Note that from the LQAS method only an “acceptable” or “not acceptable” conclusion can be made about the individual lots, because the sample size in each lot is too small to provide accurate estimates.

If the answer is no, the 30 by 7 cluster sample will be much more cost-effective than the LQAS method.

2) *Are the subpopulations heterogeneous or homogeneous?*

If the subpopulations are heterogeneous (i.e. the subjects within the subpopulations are quite variable but there is little difference, on average, from subpopulation to subpopulation), then no information will be lost by not sampling all of the subpopulations, as with the 30 by 7 cluster sample.

If the subpopulations are homogeneous (i.e. the subjects within the subpopulations are similar but there are big differences, on average, between the subpopulations), then the LQAS method would be more appropriate because elements from each of the subpopulations will be sampled. If the 30 by 7 cluster survey is used, the estimate may be biased because subpopulations with very high or very low immunization may not be included in the sample. Using one overall estimate to describe the whole population may be misleading, and it may be more meaningful to judge each subpopulation separately.

3) *How difficult is it to obtain a list of all the units in the population?*

If it is very difficult to obtain a list of population units, it may be easier to use the 30 by 7 cluster sample, because: (i) a list of units is only needed for those selected clusters, and (ii) according to the 30 by 7 cluster method, only the first household is randomly selected.

If it is easy to obtain a list of the population units, taking a random sample is relatively simple and the most unbiased method. Having a list of the population units makes the LQAS method much easier to implement. Note that if it were possible to randomly select all seven households for the 30 by 7 cluster sample, the possible biases usually associated with this method would be eliminated. However, the design would then be that of a traditional cluster sample rather than a 30 by 7 sample.

4) *What is the desired precision of the estimate?*

The 30 by 7 cluster sample is set up to obtain a 95% confidence interval to within ± 10 percentage points of the population parameter. The sample size calculation is based on an assumed proportion of immunization coverage of 0.50. If the coverage is greater or less than 50%, the confidence interval is likely to be somewhat narrower than ± 10 percentage points. Nevertheless, if a greater level of precision is desired, the sample size can be increased. However, for a two-stage cluster sample, there is no simple equation to calculate sample size. Different combinations of the number of clusters and number of units selected per cluster will yield different levels of precision. The optimal combination depends upon numerous assumptions about the population with respect to the costs of sampling additional clusters and sampling additional units per cluster, as well as the within and between cluster variability.

For the LQAS method, the sample size is based on a hypothesis test, not on the estimation of a confidence interval. However, the sample size needed to obtain an overall estimate with a certain precision from a stratified random sample can be easily obtained using a simple equation.

5) *Is the event of interest very rare or very common?*

Note that the sample size for the 30 by 7 cluster sample is based on a population proportion of 0.50, which yields the greatest estimate of variability and therefore the most conservative sample size. However, if the event of an immunized, or not immunized subject is very rare, a precision of ± 10 percentage points may not be satisfactory. In neonatal tetanus, for example, the incidence is only approximately 1 in 1000, and to obtain an estimate that would be somewhere between 0 and 10% would not provide useful information. Therefore, for events that are very rare or very common, a larger sample size will be needed from a cluster sample to obtain a reasonable level of precision. For example, to estimate the prevalence of neonatal tetanus to within 50% of the true value (i.e. between 0.0005 and 0.0015) with 95% confidence, a total sample size of 15 352 would be required for a simple random sample. Given that the variability is larger for a cluster sample than for a simple random sample, an even larger sample would be needed for the former. If we assume that the variability from the cluster sample to be twice that of a simple random sample, the overall sample size from the simple random sample would need to be doubled to obtain the same level of precision as from a cluster sample. For the neonatal tetanus example, an overall sample of 30 704 subjects would be needed, indicating that 1024 subjects from each of the 30 clusters would have to be sampled.

The sample size for LQAS is based on the hypothesized (or desired) immunization coverage. Therefore the rarity of an event is already taken into consideration when the sample size is calculated.

6) *What knowledge is there about the actual level of immunization coverage in the population?*

When using the LQAS method, numerous parameters need to be set to obtain the sample size and decision value for the lots. To obtain these values, assumptions about the population need to be made about the actual level of coverage that can be realistically obtained, and about the current level of coverage.

The 30 by 7 cluster sample does not make any assumptions about the population, which makes it easy to apply to many situations. Note, however, that the sample size of 210 may not be appropriate when the interest is in an event that is very rare or very common (see Question 5).

7) *What is the budget for the survey?*

This may be the most important question. In a perfect world, the sampling method would be dictated strictly by the population characteristics and the research question of interest. In reality, however, the sampling design is often dictated by cost.

The 30 by 7 cluster survey has a set sample size of 210. This sampling design is economical because only 30 clusters need to be visited, which decreases the travel time. Furthermore, a list of all the units in the population is not required, which makes the sampling more feasible.

The LQAS method is touted as being a method that requires very small sample sizes. In reality, however, this is not always true, especially if it is of interest to obtain an overall population estimate. In most scenarios, the sample size per lot is at least 7, therefore if the population is divided into more than 30 lots, the overall sample size will be greater than 210. If the subpopulations are the same as used for the cluster sample, there will be many more clusters than 30, and the overall sample size will be much larger than 210. In addition to the possibly large sample size needed to estimate an overall population proportion, the LQAS method can also be more costly given that samples have to be taken from every subpopulation, which increases the travel time and cost, and because of the need for a list of all the units in the population. Double sampling can be used to decrease the sample size, but this modification is only useful when the interest is to classify individual lots as acceptable or not acceptable. Double sampling is not beneficial when it is intended to combine the information from each of the lots to calculate an overall proportion.

8) *What is the experience level of the field workers?*

In terms of setting up the survey, the 30 by 7 cluster sample is very simple. It is set that 30 clusters will be selected with probability proportionate to size and within each cluster seven subjects will be selected. There may be some difficulty in selecting the first household, given that there are a variety of methods for doing so (e.g. going to the centre of the village and spinning a bottle to get a random direction, enumerating the houses in that direction and randomly selecting one).

On the other hand, before the sampling can begin for a LQAS sample, a number of parameters need to be set from which the sample size and decision value will be calculated. And a list of all the sample elements in the lots needs to be obtained. However, once the list is obtained, the sampling is straightforward because the surveyor knows exactly which units to sample.

Table 1: 30 by 7 cluster sample versus the LQAS method to obtain an overall population estimate

Issue	30 by 7 cluster sample	LQAS (As used to obtain an overall population estimate)
<i>Sampling design</i>	Two-stage cluster sample	Stratified random sample
<i>Subpopulations</i>	Called clusters Usually based on geographic or political boundaries Supposed to be heterogeneous	Called lots Usually based on geographic or political boundaries Supposed to be homogeneous
<i>Sample size</i>	N=210 (30 clusters, 7 subjects per cluster)	Dependent on the desired proportion and level of risks, may be much larger than 210
<i>List of units</i>	No need for list of units	Need for list of all units in population
<i>Basis for inference</i>	Confidence interval for estimate	Hypothesis test
<i>Outcome</i>	Overall estimate of immunization coverage, estimates from individual clusters should not be calculated	Overall estimate of immunization coverage, individual lots are judged to be acceptable or not
<i>Precision</i>	Set to be within ± 10 percentage points of the true population value	Can be set to different levels
<i>Weighting of the sample</i>	Self-weighting	Weights need to be calculated for each lot
<i>Cost</i>	Decreased travel time and preparation	Need to sample each lot, yielding higher cost
<i>Reasons for potential bias</i>	Heterogeneous clusters, the households are not randomly selected, all eligible subjects in the household are sampled	Small samples in each lot
<i>Ease of implementation</i>	The sample size is set, no need for list of all units in the population	Need to decide on acceptable proportion and risks, need for list of units in the population
<i>If rare event</i>	Need to increase sample size	Built into design of study
<i>When to use</i>	Interest in an overall population estimate obtained at a low cost	Interest in information from each lot, and a traditional stratified sample not affordable

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