

## Effective Sampling Methodology for Program Evaluation in Developing Countries

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### Abstract:

Mass Drug Administration (MDA) is a key intervention implemented to control and treat five diseases classified by the World Health Organization as “Neglected Tropical Diseases” or “NTDs” which affect more than one billion people worldwide. This approach involves the annual administration of safe and effective drug treatments to at-risk populations in endemic countries. Each national NTD control program collects a range of data including drug distribution and MDA coverage data. The Post MDA Survey serves to validate the accuracy of the country reported MDA coverage rates. There are unique challenges to designing and implementing household surveys in developing countries. This paper will present the design effect and the precision of the estimated drug coverage rates of multi-stage surveys from Niger in 2008 based on our experience working with the U.S. Agency for International Development (USAID) NTD Control Program. We will identify effective sampling methodology for program evaluation in developing countries. Specifically, we will focus on the stratification and clustering strategies and identify effective methods to reduce the sampling variance.

**Key Words:** Sampling methodology ; multi-stage cluster survey ; program evaluation

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## 1. Background

The U.S. Agency for International Development (USAID) Neglected Tropical Disease (NTD) Control Program is designed to support national NTD control and elimination programs and to integrate and scale up delivery of preventive chemotherapy for the following five targeted NTDs: Lymphatic Filariasis, Onchocerciasis, Soil Transmitted Helminthiasis (roundworm, whipworm, hookworm), Schistosomiasis, and Trachoma. Leveraging the generous donations made by pharmaceutical manufacturers GlaxosmithKline, Johnson & Johnson, Merck & Co, Inc, and Pfizer of the proven effective treatments for NTDs—albendazole, mebendazole, Mectizan® and Zithromax®, the NTD Control Program provides critical funding to allow countries receiving these donated drugs to distribute them effectively and to scale up treatment to full, national scale.

National NTD Control programs follow WHO recommended treatment guidelines for each of the targeted diseases. Treatment protocols vary depending on co-endemicities and as seen in *Figure 1*, some drugs are effective in controlling more than one NTD in affected populations. The method for drug administration which can include community-based, school-based distribution, household or mobile distribution posts depends on the disease and targeted population. Due to different guidelines, and approaches specific to each disease and the varying endemicity of disease in any given country, the national distribution protocol can be quite complex.

**Figure 1: Disease and Drug Relationship**

Diseases	Drugs
Lymphatic Filariasis (elephantiasis)	Diethylcarbamazine (DEC)
Onchocerciasis (river blindness)	Ivermectin (IVM)
Soil Transmitted Helminths (intestinal worms)	Albendazole (ALB)/ Mebendazole (MBD)
Schistosomiasis (snail fever)	Praziquantel (PZQ)
Trachoma (blinding eye infection)	Zithromax (Zx) and Tetracycline

In order to monitor program implementation, national NTD control programs determine the number of individuals treated by compiling the data recorded in registers by drug distributors during the MDA. Program managers use this information to determine if program goals are being met (WHO, 2004; WHO, 2005). Country-reported coverage rates (also known as epidemiologic coverage rates) are calculated for each disease based on the number of tablets distributed divided by the number of persons at risk for each targeted disease.

In addition to regular monitoring, a survey is conducted following MDAs every year or every two years, with a primary objective to validate the accuracy of the country reported MDA coverage rates. To do so, country-reported coverage rates are compared with the survey coverage rates.

The objectives of the post MDA survey include:

- To validate the accuracy of the country reported MDA coverage rates
- determine age- and gender-specific coverage
- collect information on why people do or do not take part in MDAs
- identify problem areas and make recommendations for improving drug coverage and improve overall control programme MDA efforts

The survey coverage rates are calculated for the distribution of drugs in each district based on the proportion of at risk individuals who actually reported ingesting the drugs divided by total number of individuals residing in all surveyed households, calculated as (WHO, 2005):

$$\frac{\text{Total \# of individuals identified by household survey as having ingested the drugs}}{\text{Total \# of individuals residing in all the surveyed households}} \times 100$$

Country-reported data are considered accurate if they fall within the survey 95% confidence interval (CI) when compared with the survey coverage rates. Country-reported data found to be above the survey CI may be indicative of over-estimation of data while country-reported data falling below the survey CI, may indicate under-reporting or missing data from their field offices/drug distributor registers.

Validation surveys have been conducted for other international health programs, including the Expanded Program on Immunization (EPI); a review of officially reported DTP3 coverage from 1990-2000 in 45 countries was found to be higher than that reported from household demographic health surveys (Murray, 2003). Validation surveys for the NTD control program are equally important, and are particularly complex since they include the integration of treatment with multiple drugs, depending on the disease endemicity in each community. The NTD control program uses a unique integrated approach to treating these diseases, which allows for efficiency and overall cost savings (Baker 2010; Richards 2006).

Highlighting the experience of implementing the post MDA survey in Niger in 2008, this paper illustrates the unique challenges to designing and implementing household surveys developed in support of national NTD control programs, specifically, we evaluate the sampling methods used for conducting the post MDA validation surveys, highlighting the post MDA survey conducted in Niger in 2008 as a case study, and propose recommendations to reduce the sampling variance.

## 2. Results from 2008 Post MDA Survey in Niger

The results from the 2008 post MDA survey in Niger are presented in **Figure 2**. The country reported coverage rates are within the estimated 95% confidence intervals for most districts and drugs. However, for some districts and drugs, the 95% confidence intervals are very wide and/or do not contain the country reported coverage. The design effects and unequal weighting effects are also presented in the **Figure 2**. Design effects (*deffs*) quantify the increase in the estimated standard errors associated with complex sample designs in comparison to standard errors estimated under a simple random sample design. It is defined as the ratio of the properly computed actual variance of an estimated parameter to the variance based on a simple random sample (SRS) of the same size. A *deffs* of 2 indicates that the sample variance is 2 times larger than it would be for a simple

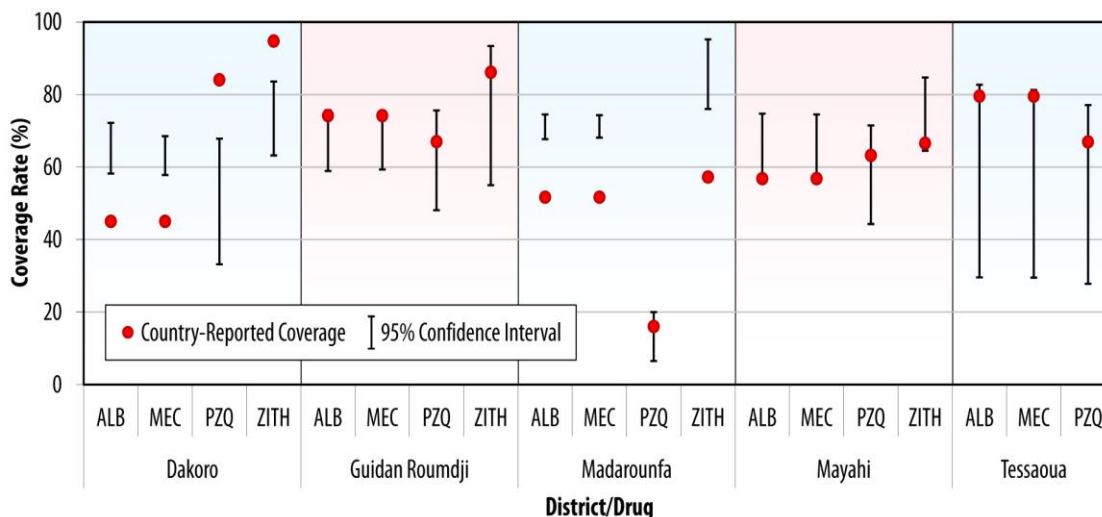
random sample. The design-based variance reflects the effects of the following three study design features: stratification and clustering, unequal weighting of the observations; and over or under sampling of subgroups of the population. The design effects are very large for zithromax in Dakoro, Guidan Roudji, and Mayahi district, and all the drugs in Tessaoua district. The reported and estimated coverage rate for Praziquantel in Madarounfa district is extremely small compared to other drugs and districts.

**Figure 2: Summary of Design Effects & UWE by District and Drug Type**

District	Drug	Country Reported Coverage Rate	Survey Estimated 95% CI	Standard Error	Design Effect	UWE
Dakoro	ALB	45.0	(58.2–72.2)	3.2	6.0	1.13
Dakoro	MEC	45.0	(57.8–68.5)	2.9	4.9	
Dakoro	PZQ	84.1	(33.2–67.8)	5.5	8.2	
Dakoro	ZITH	94.8	(63.2–83.6)	4.4	13.3	
Guidan Roudji	ALB	74.2	(58.9–75.7)	2.9	3.0	1.10
Guidan Roudji	MEC	74.2	(59.3–75.1)	2.8	2.8	
Guidan Roudji	PZQ	67.0	(48.1–75.6)	4.5	6.6	
Guidan Roudji	ZITH	86.2	(55.0–93.4)	4.4	9.3	
Madarounfa	ALB	51.7	(67.7–74.5)	1.4	1.0	1.07
Madarounfa	MEC	51.7	(68.1–74.3)	1.4	1.1	
Madarounfa	PZQ	16.1	(6.5–20.0)	1.6	2.9	
Madarounfa	ZITH	57.3	(76.0–95.2)	2.3	6.2	
Mayahi	ALB	56.8	(58.1–74.7)	2.7	3.8	1.11
Mayahi	MEC	56.8	(58.2–74.5)	2.7	3.7	
Mayahi	PZQ	63.2	(44.3–71.5)	4.8	5.3	
Mayahi	ZITH	66.6	(64.5–84.7)	3.6	8.1	
Tessaoua	ALB	79.6	(29.6–82.7)	6.6	12.4	1.09
Tessaoua	MEC	79.6	(29.5–81.3)	6.7	12.6	
Tessaoua	PZQ	66.9	(27.8–77.1)	7.1	13.9	

The unequal weighting effect (UWE) measures the adverse effect of unequal weight variation on the precision of estimates. If all the adjusted sample weights are equal then the UWE would be one. The UWEs are very close to one for all districts, and indicates that the weights do not significantly inflate the design effect. The extremely large design effects are introduced by intracluster homogeneity. This homogeneity may be due to distribution mechanisms, urban & rural areas, and other factors. In most of the clusters the drug was distributed by only one field person and this may have introduced bias in the coverage rates. The most frequent reasons for not taking the drug were listed as: drug distributor did not come, drug was finished, and absent during drug distribution.

The country reported coverage rates and the estimated confidence intervals of coverage rates from the post MDA survey are presented in *Figure 3*. For some districts, the confidence intervals are very wide and/or do not contain the country reported coverage.

**Figure 3: Country Reported vs. Survey Epidemiologic Coverage Rates by District**

In Dakoro district, the country reported coverage rates for albendazole and Mectizan® are below the 95% confidence interval; and praziquantel and Zithromax® are above the confidence interval. In Madarounfa district, country reported coverage rates for all the drugs are below the 95% CI except for praziquantel.

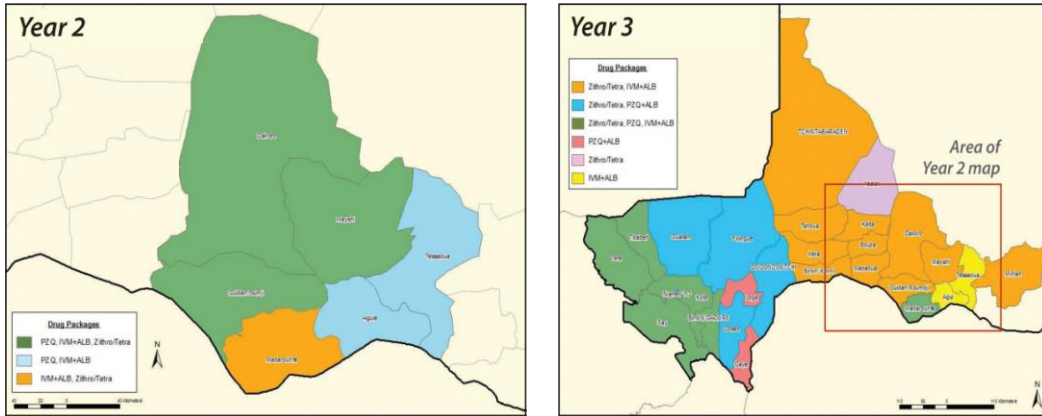
### 3. Survey Design

#### Survey Design for 2008

A multistage cluster sample design was used for the 2008 survey. The survey was limited to the Maradi region which consists of six districts. The primary sampling unit (PSU) was the community health center area, which consists of five to twenty villages. For each of the three drug packages ten PSUs were selected using the probability proportional to size (PPS) sampling method, with a total of 27 unique PSUs selected from these multiple drug combinations. From each PSU four villages were selected and ten households were selected from each village using simple sampling. All household members were included in the survey. Approximately 5,940 individuals were surveyed. The data was analyzed using SAS 9.2 and SUDAAN 10 software.

The distribution of different drugs varies geographically within the country depending on the disease prevalence. Drug distribution in the target areas for 2008 and 2009 (Year 2 and 3 respectively) are defined as shown in the maps in *Figure 4*. For 2008, the survey was conducted only in one district and had only three different drug packages. As the national program was scaled-up, the sampling design became more complex. By year three, there were six different drug package combinations needed based on the endemicity of additional districts.

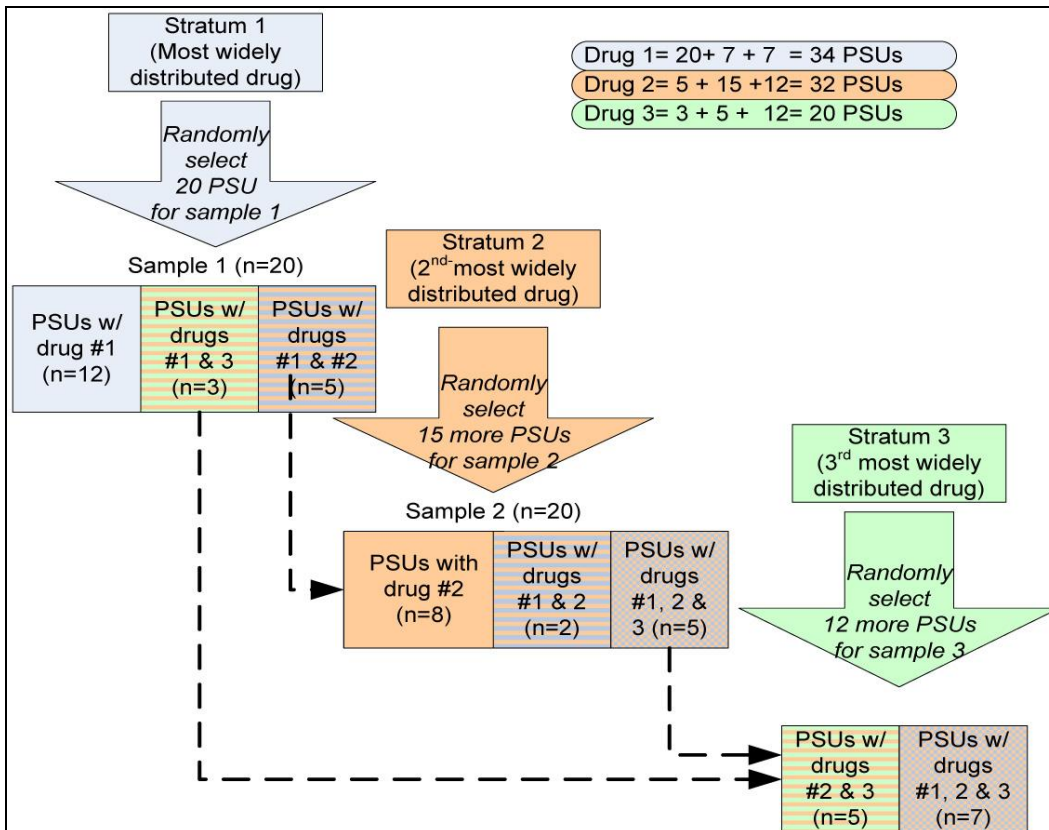
**Figure 4. Districts in Niger Targeted for Post-MDA Coverage Survey Sampling, Years 2 and 3**



**Recommended Sampling Methodology: Stratification by Drug Package**

The areas receiving each drug package overlap, which requires a strategy that is practicable and yet respects basic sampling principles. To address this issue the communities were stratified by drug/drug packages that overlapped. This ensured that an adequate sample size was drawn to validate drug specific coverage rates.

**Figure 5: Flowchart of Sample Selection by Drug Package**



In future years we recommend increasing number of PSUs to 20 for each drug. The suggested sampling methodology was to list all areas that have received the most widely distributed drug package. First, draw the desired sample from this stratum using systematic PPS: Sample 1 from Stratum 1. Then turn to Stratum 2, consisting of areas with the next most widely distributed drug package and identify those areas in Sample 1 that belong to Stratum 2. Select an additional sample of areas in Stratum 2 from those areas not in Sample 1. Continue repeating this process until we have the desired sample size for each drug/package. The flow chart of sample selection by drug package is presented in *Figure 5*.

The calculations of the sample selection probabilities are complicated because the strata in this design are not mutually exclusive and some areas could be selected in the first, second, or third stage depending on the number of unique drug packages. The derived formulas for the sampling probabilities and design weights are out of the scope of this paper.

#### 4. Discussion

In general, most of the 2008 country reported coverage rates were within the 95% CI estimated by the survey, which reflects well on the data reporting methods for this country. In Niger in particular, country reported rates were within the CI for 12 of the 19 district/drug combinations; the country reported rates were lower than reported rates for most of the incongruent cases. Reasons for this include inaccurate estimates of the denominator population figures and/ or lack of completeness of reporting by drug distributors. It is interesting to note that reported rates were not often above the survey coverage rates, which means that programs may actually be doing better than is reflected in their reporting.

There were some common issues identified in all NTD program countries in implementing the post MDA survey design that can and should be addressed. In some countries if a village was inaccessible, the field teams often replaced the village themselves while in field; thus, the sample is not fully random. Most of the counties recorded incomplete data. Nonrespondent households and subjects were not recorded/included in the data. As a result, accurate non-response weighting adjustment could not be done and this may have introduced bias. The raw data often contained inconsistent district and village names that did not match with the sampling frame. Administrative data that accompanies the survey data were not always properly recorded, which created difficulties in analyzing data and caused time delays for the analysis. E.g., in many instances, the selected village was divided into two villages and/or renamed after the sample was selected but this was not documented.

Based on survey results from all countries where the Post-MDA Survey has been implemented, we offer the following suggestions to improve design efficiency.

- Increase the number of selected PSUs to reduce the large design effects. We recognize this is often not possible due to budget constraints. If the budget does not allow for a large enough selection, the survey could be conducted on a smaller population (e.g. in one region of the country instead of nationwide), or less frequently (e.g. once every 2 or 3

years). In some cases it may be preferable to not conduct the survey at all rather than to have such a small number of PSUs that the data are not statistically representative.

- Alternatively, stratify within the districts, which may reduce design effects. Urban areas may have higher coverage rates compared to the rural areas due to accessibility. Stratifying within districts by urban and rural may reduce the design variance.

- Create a survey design that is as simple as possible. A more informed, less complicated design will make the sample selection and data collection easy and efficient to execute, and improve quality assurance. The design stratified by district and/or urban and rural area can be easier to implement compared to stratifying by drug. However, this may increase the UWE due to the disease distribution.

- Communicate the importance of randomness to maintain the data integrity (e.g., not replacing selected villages while in the field).

- Provide detailed training to implement the sampling methodology and data collection plan. A standard training module should be used that ensure that the sample frame and sample selection information is properly documented so that weights can be calculated correctly. Also, train staff to record nonrespondent information.

- Monitor the data collection more closely to identify problems that can be resolved during data collection stage; for instance, monitoring during the data collection process will ensure non-respondent information is collected, selected villages matches with the sampling frame. Any discrepancy noticed during the data collection can be resolved for the remaining sample. But these issues are difficult and costly to resolve after the data collection is done.

- Increase the number of drug distributors in each cluster to reduce distributor's bias.

- Modify questionnaire to include drug distribution mechanism to identify if this affects coverage rates. Countries collected additional information on the process of the drug distributions at the district level. However, most districts used more than one distribution methods and this does not provide person level information to identify which method is more effective to reach more people.

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