# NCD Mobile Phone Survey
# Sampling Design

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# 1. INTRODUCTION

## 1.1 Overview

Noncommunicable diseases (NCDs) are the leading cause of death worldwide. Efficient monitoring and surveillance are cornerstones to track progress of NCD burden, related risk factors, and policy interventions. The systematic monitoring of risk factors to generate accurate and timely data is essential for a country's ability to prioritize essential resources and make sound policy decisions to address the growing NCD burden.

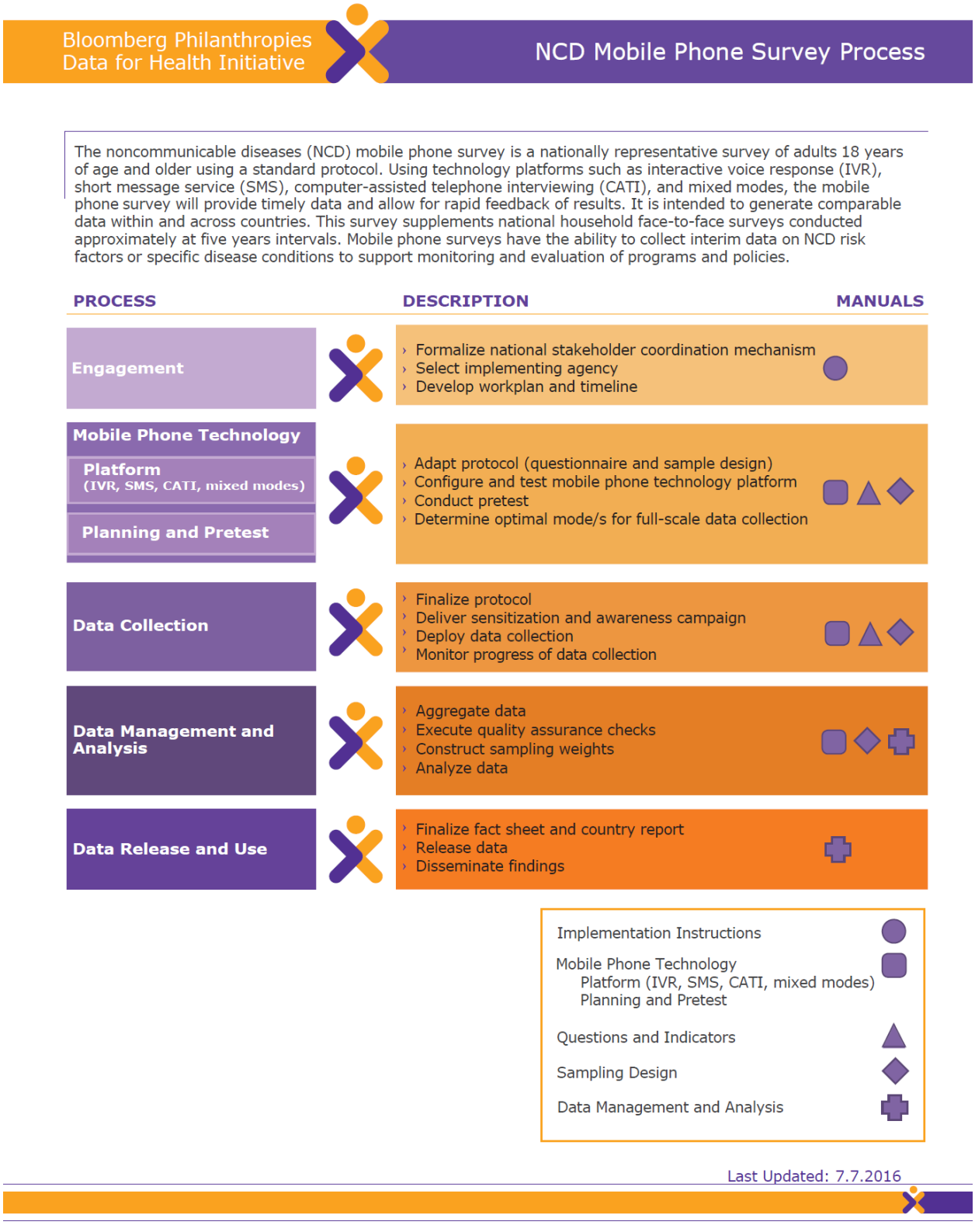
With increasing access and use of mobile phones globally, opportunities exist to explore the feasibility of using mobile phone technology as an interim method to collect data and supplement household surveys. Such technologies have the potential to allow for efficiencies in producing timely, affordable, and accurate data to monitor trends, and augment traditional health surveys with new, faster mobile phone surveys.

The Bloomberg Data for Health initiative aims to strengthen the collection and use of critical public health information. One of the components of the initiative aims to explore innovative approaches to NCD surveillance, including the use of mobile phone surveys for NCDs. The main objectives of this component are to assess the feasibility, quality, and validity of nationally representative NCD Mobile Phone Surveys and propose a globally standardized protocol. The specific objectives are to:

- Implement mobile phone surveys in 10 countries and support face-to-face STEPS surveys in six overlapping countries
- Compare findings from the two methodologies

The NCD Mobile Phone Survey is a nationally representative stratified survey of adults 18 years of age and older. The survey uses standardized instruments and procedures reviewed and approved by international experts. This includes a core questionnaire with optional questions, sample design utilizing random digit dialing (RDD), data management procedures, and data collection using single or mixed-mode technology such as interactive voice response (IVR), short message service (SMS), and computer-assisted telephone interviewing (CATI). The implementation process consists of five stages: 1) engagement and orientation; 2) mobile phone technology and pretesting; 3) data collection; 4) data management; and 5) data release and use. Details on each stage are presented in the NCD Mobile Phone Survey Process Chart (see **Figure 1**).

**Figure 1. NCD Mobile Phone Survey Process Chart**



## 1.2 Purpose

This manual is designed to briefly outline the requirements and guidelines for countries to follow as they develop an appropriate sample design for their implementation of the NCD Mobile Phone Survey:

- **Survey Design Objectives.** Summarizes the survey objectives.
- **Target Population and Sampling Frame.** Presents a definition of the target population for the survey and provides discussion of the sample frame that will be used.
- **Basic Survey Design Specification.** Presents the basic features of the sample design that are required to achieve established levels of statistical quality and facilitate between country comparability.
- **Overview of the Sampling Approach.** Presents the recommended sampling designs for options 1 and 2.
- **First Phase of Sampling.** Presents the recommended approach for selecting mobile phone numbers (MPNs).
- **Second Phase of Sampling.** Describes how the sample will be stratified after selection of MPNs.
- **Determining Sample Sizes and Response Rates.** Provides guidance on determining the selected sample sizes needed to produce a respondent sample size and computing the final eligibility and response rates for the survey.
- **Computing Final Sample Weights.** Outlines the five steps for computing the sampling weights for statistical analysis.

# 2. SURVEY DESIGN OBJECTIVES

Sample design requirements for the NCD Mobile Phone Survey have been developed so that unbiased population estimates of behavioral health risk can be generated for the target population of each country and for two analysis groups of interest defined separately by age or sex.

The allocation of the sample will be accomplished by explicitly stratifying the second-phase sample by age group (i.e., 18–29, 30–44, 45–59, and 60 years and older) and sex (i.e., male and female) with disproportionate allocation (to the mobile phone user population) among strata to produce a final respondent sample of mobile phone users that resemble the joint age group by sex distribution of the general population (as defined by the National Statistics Office or other reputable sources, such as the *World Population Prospects: The 2012 Revision* from United Nations Department of Economic and Social Affairs Population Division).

Designing the survey to generate precise joint estimates by sex and age group is preferred for the NCD Mobile Phone Survey, primarily to allow comparisons of estimates by these domains between different countries participating in this effort.

## 2.1 Deciding on a Sample Design

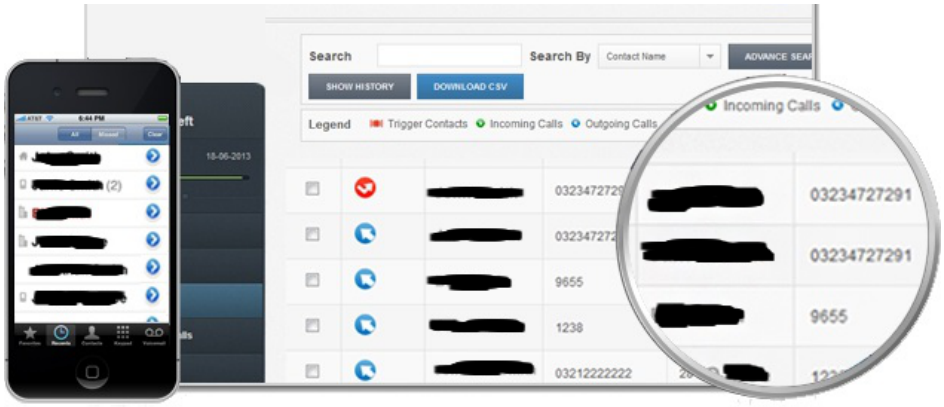
This manual provides a general statistical template for the randomly selected samples that should be used for the NCD Mobile Phone Survey. The purpose of this section is to present several options and design approaches currently relevant to the pilot testing phase of the survey protocol, where some countries have already done a NCD Mobile Phone Survey and others are looking to complete a NCD Mobile Phone Survey for the first time.

## 2.2 Sample Design Options for Countries Implementing the NCD Mobile Phone Survey Protocol

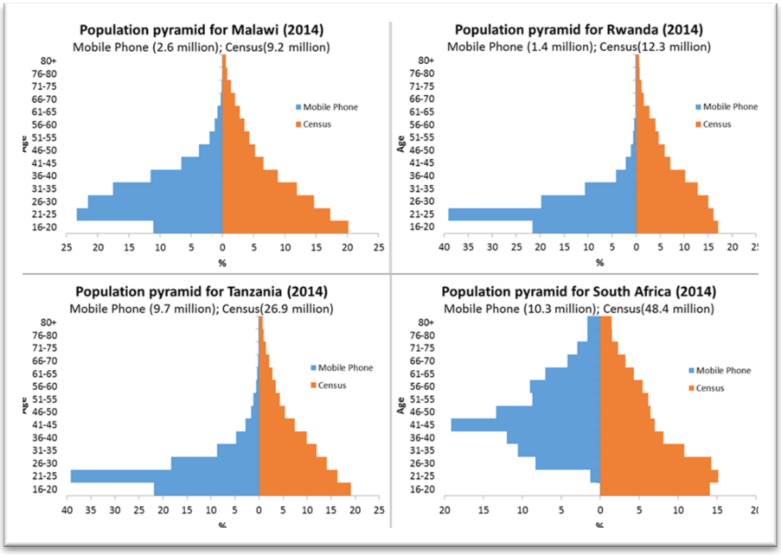
Three design options are considered in this setting:

- **Option 1.** Two-phase sampling of MPNs from an implicit MPN frame.
  - First phase – randomly sample MPNs from an implicit MPN frame of all possible MPNs.

- **Option 2.** Two-phase sampling of MPNs from an <u>explicit</u> frame of user account MPNs.
  - First phase – randomly sample MPNs from an <u>explicit</u> MPN frame of available MPNs provided by the telecommunication operators.




- **Options 1 and 2.** Second phase – sample stratified proportional to the general population but disproportionate to the mobile phone user population



- **Option 3.** Stratified Multi-Stage Cluster Sample
  - Split-sample household-level integration with the STEPS stratified multi-stage cluster sample


These sample design options are described in more detail in **Section 3**.

# 3. TARGET POPULATION AND SAMPLE FRAME

## 3.1 Definitions of the Target Population and Study Eligibility

In general, the target population for the NCD Mobile Phone Survey should include all eligible individuals, 18 years and older, with MPNs within the country's MPN series (refer to the ***Mobile Phone Technology Manual*** for definition). To propose an exclusion, a country should explicitly define which MPN ranges are included in and excluded from the target population and provide an estimate of the percent of the population that resides in those ranges being excluded. This percentage will provide an indication of the potential bias effect of any real exclusions on estimates that are otherwise intended to be national in scope.

The target population for the NCD Mobile Phone Survey should include men and women who are 18 years of age and older. This definition is important when completing the demographic questions, which determines who is eligible to complete the NCD questions.

## 3.2 Sampling Frame

In general, a sampling frame is a list of all eligible members of the target population from which the sample could be drawn. For the NCD Mobile Phone Survey, the type of list depends on the study design:

**Option 1.** Two-phase sampling of mobile phone users from an *implicit* frame of MPNs, with stratified sampling disproportionate to the mobile phone user population in the second phase.

- An *implicit frame* is an implied sampling frame produced from the range of all possible MPNs in the country, some of which will not currently be in service. This frame will be constructed in collaboration with the country's telecommunication regulatory agency.
- For this study design, a comprehensive list of all survey-eligible individuals in a country likely does not exist, making sampling from the preferred frame virtually impossible. Consequently, an indirect list frame should be used to select the sample. This list is implied by the known set of possible MPNs that could be assigned by providers to their customers.
- This option is preferred whenever a reputable national listing of MPNs currently in service is unavailable.

**Option 2.** Two-phase sampling of mobile phone users from an *explicit* frame of MPNs, with stratified sampling disproportionate to the MP user population in the second phase.

- An *explicit frame* is a list of MPNs provided by the telecommunications operators. This frame may or may not be a complete list of MPNs subscribing to the telecommunications operator's service.
- From this frame, the first-phase sample of MPNs is selected from a provider-produced list of current MP subscribers.

**Option 3.** Split-sample household-level integration with the STEPS stratified multi-stage cluster sample.

- A *cluster frame* is a list of entities that provide indirect links to multiple individuals in the target population by grouping them somehow (e.g., a list of a city's schools, each being a grouping of students to be sampled, or a list of the room's file drawers, each being a grouping of files to be sampled). This method is called a cluster sample because a sample of clusters should be selected first, and then the sample of individuals is identified from the individuals linked to the selected clusters.
- For a planned STEPS household survey, a cluster sample of geographic areas within the country is randomly selected, a complete list of all households within each selected area is constructed, a sample of households is randomly selected from each list, and one individual is randomly selected for interview from a randomly designated subset of the selected households in each sample area. This type of multi-stage cluster design assumes that each selected survey-eligible individual can be linked to a household in the country.
- Mobile phone users in selected STEPS households that are *not* earmarked for data collection in STEPs are recruited for participation in the mobile phone survey. If recruited participants do not have a mobile phone, they will be provided one, along with instructions on how to use them for the survey.
- This sample design option is dependent on a household survey being conducted and assumes that respondent provides a mobile phone number and that the provided mobile phone number does not change from the time it was collected to the time the mobile phone survey was initiated. Any biases, measurable or unmeasurable, in the design of the household survey would be reflected in the mobile phone survey estimates.

The rest of this document describes methods for implementing options 1 or 2. Instructions for option 3 will be provided after data collection in the initial countries is complete.

# 4. SURVEY AND SAMPLE DESIGN

## 4.1 Basic Survey Design Specifications

The *sampling unit* during sample selection refers to the entities that are selected for the survey. In this survey, the sampling units are randomly generated MPNs. For the NCD Mobile Phone Survey, stratification cannot occur until after the sample is selected. In such cases, two-phase sampling can be used to control the demographic composition of the final sample.

If sample design Option 1 is chosen, the NCD Mobile Phone Survey sample design will reflect a two-phase sample of mobile phone users from the sampling frame of possible MPNs with stratified sampling disproportionate to the MP user population in the second phase. Within each stratum, each mobile phone user linked to a single MPN will have the same probability of being selected if an equal-probability selection method (e.g., simple random sampling) is used to select the MPN in the first phase. However, the selection probabilities for users with access to multiple MPNs will be directly related to the number of mobile phones they can access (i.e., resulting in a multiplicity adjustment). Selection probabilities will also be inversely related to the number of users when multiple mobile phone users are linked to a single MPN (i.e., a MPN cluster) and only one of them is invited to be interviewed in the survey. These selection probabilities, along with the probability of selecting MPNs in the first phase, will be used in calculating sampling weights.

In the first phase for Option 1, a sample of MPNs is randomly selected from the range of possible MPNs. Respondents selected for the NCD Mobile Phone Survey are screened and assigned to one of several strata categorized by age group and sex. In the second phase, NCD data are collected on respondents within age/sex strata until individual stratum sample sizes are achieved or until the data collection period determined by countries has expired. Once sample size is met in a specific stratum, data are collected for the demographic questions, but not the NCD questions, until the targeted respondent sample sizes for all strata are attained.

As noted in the Introduction, certain requirements and recommendations should be followed to maximize the comparability of the results between countries that are conducting the NCD Mobile Phone Survey. However, each country has the option of introducing design enhancements that allow it to increase the usability of the results from this survey (e.g., selecting the sample to ensure precise estimates by region). In this section, we present some of the basic survey design requirements. Any design enhancement that a country wants to introduce will generally be acceptable provided it does not interfere with these basic requirements and, thus, contribute to a loss of intercountry comparability of survey estimates.

For the purposes of clarity in discussion of sampling features, including sampling weights and adjustments, the demographic questions and questions targeting multiplicity and clustering will be referred to as the Demographic Module and the NCD questions will be referred to as the NCD Module.

## 4.2 Sample Design Features

Requirements related to the sample design and sampling weights include the following:

- Simple random selection (SRS), without replacement, should be used so that every member of the explicit or implicit sampling frame of mobile phone users has a computable, nonzero chance of being selected into the sample.
- Sample strata are constructed based off the known distribution of the general population from official population data (e.g., recent census) because the distribution of the MP user population is not known. Once data is collected the MP user population distribution will be estimated based on age and sex. This estimated MP user population distribution and the known general population distribution will be used to adjust the sampling weights.
- Randomly selected mobile phone users should be enrolled into both the Demographic Module and the NCD Module until the appropriate respondent sample size for a given stratum is met or the data collection period has expired.
- Once a stratum respondent sample size is met, members of the fulfilled stratum should continue to contribute to the Demographic Module until all strata are filled. These data on age and sex will be necessary for the post data collection adjustment of the sampling weights, hence final recruitment status throughout data collection should be retained for later use.
- Survey nonparticipation because of ineligibility and nonresponse should be tracked to properly compute response rates in the NCD Mobile Phone Survey. For instance, MPNs may not be active, a mobile phone user may be under 18 years of age and ineligible for the survey, an eligible mobile phone user may refuse to participate, or an active MPN may lose connection to the mobile platform system during an interview. A list of all applicable disposition codes will be assigned to all MPNs selected for the survey to document eligibility and nonresponse. If local definitions of these codes are used, they should be standardized to the codes provided in this manual. Conversion rules of these codes between local and standard definitions should also be provided.
- Clustering and multiplicity associated with mobile phone usage should also be tracked. Clustering occurs when a single MPN is shared among multiple people. Multiplicity occurs when a respondent has access to multiple MPNs. This information is used to compute/adjust the base weight. The reciprocal of the responding user's multiplicity and the cluster size for the MPN are multiplied to the inverse of the MPN's selection probability to produce the adjusted base weight.

## 4.3 Sample Sizes and Expected Precision

Requirements and recommendations related to respondent sample size are based on the following indicators of statistical quality that were established for NCD Mobile Phone Survey:

- The survey should be designed to produce estimates that meet the following precision requirements: estimates computed at the national level by age, by sex, and by the cross of sex and age should have a 95% confidence interval with a margin of error of 5 percentage points or less for NCD risk factor rates of 50%.
- The design effect ($Deff_o$) associated with any particular estimate from a survey is defined as the multiplicative factor increase in the variance of survey estimates because of complex survey design features, such as unequal weighting and clustering. The multiplicative effect as a result of variable weights, defined here as $Meff_{Wts}$, is multiplied times the comparable effect for cluster sampling ($Meff_{CS}$) to produce the overall value of $Deff_o$. By definition, $Deff_o$ is the ratio of the variance of an estimate based on the complex survey design relative to the corresponding variance of the same sample size using simple random sampling. While it is theoretically possible to observe $Deff_o < 1.00$, in practice, the complex design features of a survey nearly always have a detrimental effect on precision of the estimates. Therefore, for survey studies with complex designs, the design effects will typically be greater than 1.00, and $Deff_o$ can be much greater than 1.00.
- For the NCD Mobile Phone Survey, sample weights will be variable mostly because of sample variation in second-phase stratum sampling rates. This variability among final sample weights increases the variance of survey estimates by a factor of $Meff_{Wts}$, which may be approximated by $Meff_{Wts} \approx 1 + \{CV_{Wts}\}^2 \geq 1.00$, where $CV_{Wts}$ is the coefficient of variation among all sample weights. Previous work (Leo, 2015) suggests that $Meff_{Wts}$ in mobile phone surveys can be sizable, with observed values of 1.8 in Zimbabwe, with about 80% mobile phone market penetration; 5.2 in Mozambique, with about 40% mobile phone penetration; 6.3 in Afghanistan, with about 60% penetration; and 11.6 in Ethiopia, with about 17% mobile phone penetration. Not surprisingly, $Meff_{Wts}$ and mobile phone market penetration rates are inversely related because lower penetration requires more disproportionate sampling or calibration adjustments to the mobile phone user population to match relevant demographics of the NCD Mobile Phone Survey target population, thereby leading to more variable final weights.
- Most quantitative indicators of the statistical quality of estimates from sample surveys are mathematically related to the variance of estimates among all possible outcomes of the survey design. When limiting our attention to health-related estimates of some proportion *(P)* (informed by a country's specific health policy and goals) in the population of those at risk of adverse health outcomes, we have that the variance of the estimator *( $\hat{P}$ )* among all possible outcomes of the sample design is approximately,

$$V(\hat{P}) = \left[Deff_o\right]\frac{P(1-P)}{n_r} = \left[Meff_{Wts}Meff_{CS}\right]\frac{P(1-P)}{n_r} \quad , \qquad \text{(Eq. 1)}$$

Where $Deff_o = Meff_{Wts} * Meff_{CS}$ is the overall design effect (Gabler et al., 1999) $Meff_{CS}$ is the multiplicative increase in variance due to the use of cluster sampling, and $n$ is the number of sample respondents used to produce the estimate of $P$. From Eq. (1) we see that statistical quality under all three sample design options would be influenced by $n$, the actual size of $P$ and the value of $Meff_{Wts}$ associated with the particular design option. Experience (Gabler, 1999) indicates that $Meff_{Wts}$ could be quite large in Options 1 or 2, particularly in countries with lower MP penetration. In this instance, highly disproportionate sampling or major calibration adjustments are

needed for the weighted respondent sample to match the target population for subgroup comparisons, and both $Meff_{CS}$ and $Meff_{Wts}$ will be more moderate in size.

- The design of the sample should correctly reflect anticipated levels of nonresponse and ineligibility in determining how many MPNs should be selected to yield the recommended number of respondents. For example, a person selected for interview may refuse to participate (nonresponse). Similarly, a selected MPN may prove to not be in service or selected persons may indicate they are less than 18 years old and are therefore ineligible. Rates of eligibility and response among eligible mobile phone users are multiplied to determine the overall attrition rate in samples. These components of attrition during sample recruitment should be estimated as accurately as possible from recent relevant survey experience, regardless of which sample design option is proposed.

For example, suppose the survey in a country following Option 1 is designed to produce $n_f$ female respondents and $n_m$ male respondents, and it expects to observe the following parameters shown in **Table 1**.

**Table 1. Example parameters for sample size computation**

| Rate | Comment | Assumption |
|---|---|---|
| **Active Number Rate (ANR)** | Accounts for those MPNs selected via RDD but determined to be non-active numbers | 20% |
| **Eligibility Rate (ER)** | Accounts for those cases when respondents are interviewed for the survey and later determined to be ineligible (e.g., they younger than 18 years old) | 50% |
| **Response Rate (RR)** | Accounts for those eligible respondents who are selected but do not complete the Demographic Module and at least one question in the NCD Module | 30% |

The actual values assumed for the active number rate, eligibility rate, and response rates should be informed by the results of the pretest and information obtained about the population age and sex distribution from certified sources (e.g., recent census, United Nations projections).

The formula for calculating the effective sample size is as follows:

$$n_{eff} = \frac{n}{ER * RR}$$

In addition, to achieve this effective sample size, we further need to determine how many MPNs to dial ($n_{MPN}$) by adjusting for the active number rate (ANR), as follows:

$$n_{MPN} = \frac{n_{eff}}{ANR}$$

where ER, RR, and ANR are defined in **Table 1**.

Additional guidelines for determining an appropriate sample size at each step of the NCD Mobile Phone Survey sample design are provided in **Section 8.**

# 5. OVERVIEW OF THE SAMPLING APPROACH

The sample for Options 1 and 2 of the NCD Mobile Phone Survey should be selected using a multi-phase, stratified design to ensure the respondent sample closely matches relevant demographics of the entire target population. In summary, this sample selection process should proceed as follows.

The first phases of the design involve randomly selecting MPNs. This selection process is highly dependent on how the MPN assignments and recordkeeping are handled in the particular country that is fielding the survey.

The selected sample for each of the age and sex strata defined for sampling in the second phase of the design for Options 1 and 2 should be allocated so that the final respondent sample is proportional to the age-by-sex distribution of the country's target population. The age-by-sex distribution of the country's target population can be constructed from a recent census, administrative records, or a recent large and reputable demographic survey and, in general, should equal the total eligible population, 18 years of age and older. If NCD Mobile Phone Survey target population counts are not available, corresponding total population counts can be used as stratum-size measures.

MPNs should continue to be collected until all strata sample sizes are achieved or until the data collection has expired.

# 6. FIRST PHASE OF SAMPLING: SELECTING MPNS

The recommended sampling process for countries that will select their ultimate sample of MPNs in Option 1 is somewhat different than for those countries implementing Option 2. Guidelines for all these scenarios are presented below.

## 6.1 Countries Selecting MPNs

Countries that plan to select MPNs using Option 1 should follow the following guidelines:

- MPNs should be generated in volumes that can be reasonably managed by the computing and network capacity.
- Because the number of MPNs selected as specified by the sample design will likely vary by a considerable amount, MPNs should be selected via SRS using RDD without replacement for Option 1 and via SRS without replacement for Option 2 to provide a simple random sample. This variation in the number of MPNs selected can be due to many possible sources, such as MP market penetration, aversion to surveys by the public, or percent of possible MPNs actually assigned.
- Methods can be used to improve the sample of MPNs with RDD in Option 1, including number validation. These methods increase the proportion of working MPNs in the sample by screening out invalid or inactive numbers prior to fieldwork. An initial sample of MPNs can be drawn from a sampling frame of randomly generated MPNs that is first screened to exclude banks reserved for operator technical services. These numbers can be further screened for voicemail and operator messages to be classified as unknown eligibility if eligibility status cannot be determined.
- It is important that every MPN on the sampling frame has some nonzero probability of selection and that the probabilities of selection are retained in the final analysis file. These probabilities of selection are one of several pieces of statistical information that are used to compute sample weights for the ultimate respondents to the NCD Mobile Phone Survey.

# 7. SECOND PHASE OF SAMPLING: SELECTING AND STRATIFYING ELIGIBLE MOBILE PHONE USERS

After the MPNs are selected for the NCD Mobile Phone Survey under Options 1 and 2, the next phase of the sample design involves stratifying the final sample.

The prevalence of most chronic disease risk factors tends to increase with age and vary by sex. Therefore, survey results should include estimates for specific age groups for each sex in addition to the total survey population estimates to provide a more nuanced picture of the prevalence of chronic disease risk factors in your target population.

The recommended age groups are 18–29, 30–44, 45–59, and 60 years and older, though any age groups may be used. Estimates may be obtained only for the entire age span of the survey (e.g., 18 years and older) or for less age groups (e.g., 18-29, 30 years and older).

A country's final sample design should include a detailed description of how a country plans to form a suitable sampling frame for the selection of MPNs, how the country will address frame incompleteness (such as new mobile phone operators opening for business during data collection), and how randomization will be used to select the sample of MPNs.

The planned allocation of the sample mobile phone users will be accomplished by explicitly stratifying the second-phase selection of users by age group (18-29, 30-44, 45-59, and 60 years and older) and sex (male and female) based on information received in the Demographic Module. Final respondent sample sizes in the strata will be proportional to the age group and sex distribution from the general population (as defined by the National Statistics Office or other reputable sources, such as the *World Population Prospects: The 2012 Revision* from United Nations Department of Economic and Social Affairs Population Division).

Randomly selected eligible mobile phone users should be enrolled into both the Demographic Module and the NCD Module until the sample size for each second-phase stratum is met.

Once a stratum sample size is met, selected members of that stratum should continue to be recruited to complete a Demographic Module until respondent sample size goals have been met in all strata or until the data collection period has expired. Counts of completed Demographic Modules and of those completing an NCD Module will be needed later for each second-phase stratum defined by age and sex to compute sampling weights.

# 8. DETERMINING SAMPLE SIZES AND REPORTING FINAL RESPONSE RATES

In this section, we provide guidance on determining the selected sample sizes needed to produce a respondent sample size in the NCD Mobile Phone Survey that will meet precision and power requirements for analysis. The sample size discussed below is the number of respondents arising out of the selected sample, after nonresponse and ineligibility are considered. We also provide guidance on computing the final eligibility and response rates for the survey. The definition of response rate and eligibility rate are particularly important because having all countries adhere to the same definitions of these rates will allow comparison of these data quality measures among countries.

## 8.1 Sample Size Calculation

In the mobile phone surveys, two types of sample sizes need to be considered. First, the respondent sample size ($n_i$) is the total number of respondents with complete or partially complete interviews. It is determined by the prevalence of the NCD risk factor, precision of the estimate, and the variation because of design and sample weights for each sex by age stratum. Second, the mobile phone number sample size ($n_{MPN}$) is the total number of mobile phone numbers required to dial to obtain the respondent sample size. This is determined by the respondent sample size, active number rate, eligibility rate, and response rate.

*In Section 8.2, we present how to determine sample size based on fixed assumptions about active mobile number rates, response rates, eligibility rates, $Meff_{Wts}$, $Meff_{CS}$, prevalence, and Margin of Error ($MOE(\hat{P})$). This approach may be appropriate when there are sufficient resources to attain the possibly large target respondent sample size(s).*

*However, it is important to realize there is an alternate approach when resources are limited. In such cases, it may be advisable to fix the overall respondent sample size in the same way as the other assumptions and examine the impact on the estimation of $MOE(\hat{P})$. Appendix A offers several scenarios taking this approach, using the same assumptions regarding active number rates, response rates, eligibility rates, $Meff_s$, and prevalence as used in the example in Section 8.2.*

Recall that MPNs should be stratified by age and sex to ensure adequate sample size in certain stratum (e.g., women age 60 years and older). Some countries may want to impose additional explicit stratification to obtain a specified sample size in other domains of interest (e.g., by region). In this section, we have provided an example assuming a reporting subgroup sample size of 384 respondents, for a prevalence of 50% and margin of error of 5%. Countries with other respondent sample sizes and features should modify their calculations accordingly.

From Eq. (1), we see that statistical quality under all three sample design options would be influenced by $n_r$, the actual size of $P$ and the value of $Meff_{Wts}$ associated with the particular design option.

*Prevalence, or proportion (P), estimates discussed below are stated in general terms. However, there are several domains for which P might be estimated.*

*For instance, there is the overall population, population subgroups defined by individual sampling strata, or population subgroups that cut across strata, such as urban/rural.*

*In the discussion and tables below, the estimator $\hat{P}$ is used to represent any of these domains.*

After solving for $n_r$ in Eq. (2) below, we see that the number of survey respondents needed to achieve a particular 95% margin of error, $MOE(\hat{P}) = 1.96\sqrt{V(\hat{P})}$, for descriptive estimates of $P$ can be determined as,

$$n_r = \frac{(1.96)^2 P(1-P)}{\left[MOE(\hat{P})\right]^2} x\left[Deff_o\right] = \frac{(1.96)^2 P(1-P)}{\left[MOE(\hat{P})\right]^2} x\left[Meff_{Wts}\, Meff_{CS}\right] \qquad \text{(Eq. 2)}$$

Note that $MOE(\hat{P})$ is a measure of the *reliability* of the estimates of *P*. All surveys that take samples from a population with the intent to generalize the results from the sample to the whole population have a possibility of error. This is because a sample can never perfectly describe the population. The higher $MOE(\hat{P})$ is, the less likely it is that the results of the survey are true for the whole population. Also note margin of error is related to the confidence interval because it is half the interval length.

For the case where $Deff_o = 1.00$, **Table 2** indicates the respondent sample size requirements for various combinations of $P$ and $MOE(\hat{P})$. For other likely settings where $Deff_o > 1.00$, respondent sample size requirements are obtained by multiplying the value from **Table 2** $MOE(\hat{P})$ times the anticipated value of $Deff_o$. Moreover, to achieve this level of precision for each of K key reporting subgroups (e.g., K = 6 if we want to achieve level of $MOE(\hat{P})$ for our estimates in each key subgroup), the overall respondent sample required is *K x* $Deff_o$ *x* $n_r$ (the required sample size from **Table 2**). Taking into account statistical power to detect change in NCD findings for P from one round of a NCD Mobile Phone Survey to another would necessitate other respondent sample size requirements than those shown here.

**Table 2. Respondent sample size ( $n_r$ ) requirements for different combinations of *MOE ($\hat{P}$)* and *P* for age-by-sex reporting subgroups when *Deff$_o$= 1.00***

| $P$ | $MOE(\hat{P})$: | | | |
|---|---|---|---|---|
| | **1%** | **1.5%** | **3%** | **5%** |
| **0.03** | 1,118 | 497 | 124 | 45 |
| **0.04** | 1,475 | 656 | 164 | 59 |
| **0.05** | 1,825 | 811 | 203 | 73 |
| **0.06** | 2,167 | 963 | 241 | 87 |
| **0.07** | 2,501 | 1,111 | 278 | 100 |
| **0.08** | 2,827 | 1,257 | 314 | 113 |
| **0.09** | 3,146 | 1,398 | 350 | 126 |
| **0.10** | 3,457 | 1,537 | 384 | 138 |
| **0.11** | 3,761 | 1,671 | 418 | 150 |
| **0.12** | 4,057 | 1,803 | 451 | 162 |
| **0.13** | 4,345 | 1,931 | 483 | 174 |
| **0.14** | 4,625 | 2,056 | 514 | 185 |
| **0.15** | 4,898 | 2,177 | 544 | 196 |
| **0.16** | 5,163 | 2,295 | 574 | 207 |
| **0.17** | 5,420 | 2,409 | 602 | 217 |
| **0.18** | 5,670 | 2,520 | 630 | 227 |
| **0.19** | 5,912 | 2,628 | 657 | 236 |
| **0.20** | 6,146 | 2,732 | 683 | 246 |
| **0.21** | 6,373 | 2,832 | 708 | 255 |
| **0.22** | 6,592 | 2,930 | 732 | 264 |
| **0.23** | 6,803 | 3,024 | 756 | 272 |
| **0.24** | 7,007 | 3,114 | 779 | 280 |
| **0.25** | 7,203 | 3,201 | 800 | 288 |
| **0.26** | 7,391 | 3,285 | 821 | 296 |
| **0.27** | 7,572 | 3,365 | 841 | 303 |
| **0.28** | 7,744 | 3,442 | 860 | 310 |
| **0.29** | 7,910 | 3,515 | 879 | 316 |
| **0.30** | 8,067 | 3,585 | 896 | 323 |
| **0.31** | 8,217 | 3,652 | 913 | 329 |
| **0.32** | 8,359 | 3,715 | 929 | 334 |
| **0.33** | 8,493 | 3,775 | 944 | 340 |
| **0.34** | 8,620 | 3,831 | 958 | 345 |
| **0.35** | 8,739 | 3,884 | 971 | 350 |
| **0.36** | 8,851 | 3,934 | 983 | 354 |
| **0.37** | 8,954 | 3,980 | 995 | 358 |
| **0.38** | 9,050 | 4,022 | 1,006 | 362 |
| **0.39** | 9,139 | 4,062 | 1,015 | 366 |
| **0.40** | 9,220 | 4,098 | 1,024 | 369 |
| **0.41** | 9,292 | 4,130 | 1,032 | 372 |

| $P$ | $MOE(\hat{P})$: | | | |
|---|---|---|---|---|
| | **1%** | **1.5%** | **3%** | **5%** |
| **0.42** | 9,358 | 4,159 | 1,040 | 374 |
| **0.43** | 9,415 | 4,185 | 1,046 | 377 |
| **0.44** | 9,465 | 4,207 | 1,052 | 379 |
| **0.45** | 9,508 | 4,226 | 1,056 | 380 |
| **0.46** | 9,542 | 4,241 | 1,060 | 382 |
| **0.47** | 9,569 | 4,253 | 1,063 | 383 |
| **0.48** | 9,588 | 4,261 | 1,065 | 384 |
| **0.49** | 9,600 | 4,267 | 1,067 | 384 |
| **0.50** | 9,604 | 4,268 | 1,067 | 384 |

We see from Eq. (2) that sample size requirements for estimates of $P$ depend on the value of $Deff_o$ for each option. Experience (Gabler, 1999) sheds some light on the magnitude of $Meff_{Wts}$ in cross-class subgroup estimation, with findings between 3.0 and 8.0. However, $Meff_{Wts}$ within class or stratum estimation is expected to be near 1.0 because our sampling strategy employs a two-phased approach of selecting MPNs with stratified sampling disproportionate to the MP user population. Two potential factors will influence stratum-level $Meff_{Wts}$: clustering around a MPN and multiplicity of MPNs. Clustering occurs when a MPN has multiple eligible users but only one of these users becomes a respondent, thus decreasing the probability of selection for each user. Multiplicity occurs when a respondent has multiple MPNs and thus an increased probability of selection. These events are further described in **Section 9**. If a country has a high prevalence of either clustering or multiplicity, then stratum-level $Meff_{Wts}$ will be greater than 1.0. It is unlikely that stratum-level $Meff_{Wts}$ will be of the magnitude of the overall $Meff_{Wts}$. Therefore, we will denote stratum-level $Meff_{Wts}$ as $Meff_S$ with a range of 1.25 to 1.75 for instruction on determining sample size.

Sample sizes should be sufficient to produce behavioral health risk estimates of acceptable precision for the overall population of each participating country and for key population subgroups defined by each of the second-phase strata. Given these requirements and the need to control the variation of respondent sample weights to control losses in the precision of survey estimates, the overall respondent sample size would be determined as follows. Based on the agreed level of $MOE(\hat{P})$ in defining precision requirements, determine $n_r$ for the smallest stratum in the general population. While it is generally recommended to limit $MOE(\hat{P})$to 5% or less, flexibility is also recommended to facilitate feasibility. For proportional sample distribution sampling, the required overall respondent sample size would be $n_r$ divided by the proportion of the general population in the smallest stratum. This approach to determining sample size targets for the overall sample and each sampling stratum has the advantage of ensuring the stated precision requirements based on the size of $MOE(\hat{P})$ will be met or exceeded for each of the sampling strata and for the overall

population estimates. A potential disadvantage of this approach is that the required overall respondent sample size could be quite large when the smallest stratum is extremely small.

## 8.2 Example Sample Size Computation—Respondent Sample Size and Number of MPNs

To illustrate the sample size computations mentioned in the previous section, suppose a country assumes the following about estimation parameters in **Table 3**:

**Table 3. Example sample size calculation for Option 1 with no stratification resulting in $Meff_{Wts}$ = 1.00**

| Rate | Comment | Assumption |
|---|---|---|
| **Active Number Rate (ANR)** | Accounts for those MPNs selected via RDD but determined to be non-active numbers | 20% |
| **Eligibility Rate (ER)** | Accounts for those cases when respondents are interviewed for the survey and later determined to be ineligible (e.g., they are younger than 18 years old) | 50% |
| **Response Rate (RR)** | Accounts for those eligible respondents who are selected but do not complete the Demographic Module | 30% |
| $Meff_{CS}$ | Increase in variance because of the use of cluster sampling | 1.00 |
| $Meff_{Wts}$ | Increase in variance because of sample variation | 1.00 |
| **MOE($\hat{P}$)** | Margin of error | 5% |
| **P** | Prevalence of NCD risk factor | 50% |

To estimate the sample size for a survey with the assumptions listed above we use the following formula from Eq. 2:

$$n_r = \frac{(1.96)^2 P(1-P)}{\left[MOE(\hat{P})\right]^2} x\left[Deff_o\right] = \frac{(1.96)^2 P(1-P)}{\left[MOE(\hat{P})\right]^2} x\left[Meff_{Wts}\, Meff_{CS}\right]$$

For this example, the respondent sample size ($n_i$) is:

$$n_i = \frac{1.96^2 * 0.5 * (1-0.5)}{0.05^2} * Deff_o = \frac{1.96^2 * 0.5 * (1-0.5)}{0.05^2} * Meff_{cs} * Meff_{Wts} = 384 * 1.0 * 1.0$$

Once active number rate, response rate, and eligibility rate are incorporated into the calculations, the total number of MPNs that should be dialed ($n_{MPN}$) to attain a respondent sample size of 384 is

$$n_{MPN} = \frac{n_i}{(ANR * ER * RR)} = \frac{384}{(0.5 * 0.3 * 0.2)} = 12{,}800$$

Therefore, if a country decides to take a SRS of MPNs to attain an overall respondent sample size of 384 to estimate a prevalence of 50% with a margin of error of 5%, the total number of MPNs necessary to dial would be 12,800.

However, in the NCD Mobile Phone Survey some sort of stratification will be employed. This affects the respondent sample size in two ways. First, stratum-level estimates mean that each stratum should be at least large enough to estimate *P* based on the assumptions for margin of error and $Meff_{Wts}$. Second, because of stratification, we should consider that $Meff_s$ (stratum-level $Meff_{Wts}$) will be greater than 1.00, as discussed in **Section 8.1**.

Considering a range of $Meff_s$ from 1.25 to 1.75, we see a range of respondent sample sizes for prevalences between 10% and 50% (**Table 4**).

**Table 4. Respondent sample size ($n_i$) for smallest stratum based on various prevalences**

| | **Base sample size** ($Meff_{Wts}$ & $Meffs$ = 1.00) | | |
|---|---|---|---|
| ***Prevalence*** | ***Meff*$_s$ = 1.00** | ***Meff*$_s$ = 1.25** | ***Meff*$_s$ = 1.75** |
| **50%** | 384 | 480 | 672 |
| **40%** | 369 | 462 | 646 |
| **30%** | 323 | 404 | 566 |
| **20%** | 246 | 308 | 432 |
| **10%** | 138 | 174 | 242 |

Therefore, the respondent sample size for the *smallest* stratum in this survey is 384 for a prevalence of 50% when $Meff_s$ = 1.00. Consider the distribution of the population age and sex strata shown in **Table 5**.

**Table 5. Example population distribution by age and sex ($\pi_{ij}$)**

| Age Groups | Males | Females |
|---|---|---|
| 18-29 | $\pi_{11}$ = 19.7% | $\pi_{12}$ = 22.4% |
| 30-44 | $\pi_{21}$ = 14.9% | $\pi_{22}$ = 15.1% |
| 45-59 | $\pi_{31}$ = 8.8% | $\pi_{32}$ = 7.6% |
| 60+ | $\pi_{41}$ = 6.1% | $\pi_{42}$ = 5.4% |

Source: Population of Bangladesh - United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2012 Revision.

The smallest stratum for this population is females 60 years of age and older. The sample size for each stratum is determined as follows, assuming the smallest stratum sample size is 384, for a proportional (to the overall population) stratified overall sample (**Table 6**):

**Table 6. Multiplicative increase of minimum respondent sample size ($n_i$) by age and sex for example population distribution**

| Age Groups | Males | Females |
|---|---|---|
| 18-29 | $\pi_{11}/\pi_{42} = 367\%$ | $\pi_{12}/\pi_{42} = 419\%$ |
| 30-44 | $\pi_{21}/\pi_{42} = 279\%$ | $\pi_{22}/\pi_{42} = 283\%$ |
| 45-59 | $\pi_{31}/\pi_{42} = 163\%$ | $\pi_{32}/\pi_{42} = 143\%$ |
| 60+ | $\pi_{41}/\pi_{42} = 113\%$ | $\pi_{42}/\pi_{42} = 100\%$ |

Based on these multiplicative increases, we see the final respondent sample sizes ($n_i$) for this survey are as follows in **Table 7.**

**Table 7. Overall sample sizes based on various prevalences and *Meff*$_S$ for an example population distribution, assuming active number rate = 20%, eligibility rate = 50%, and response rate = 30%*.**

| *Meffs* | Prevalence | 50% | | 40% | | 30% | | 20% | | 10% | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age | Males | Females | Males | Females | Males | Females | Males | Females | Males | Females |
| 1 | 18-29 | 1,409 | 1,608 | 1,354 | 1,546 | 1,185 | 1,353 | 903 | 1,030 | 506 | 578 |
| | 30-44 | 1,070 | 1,086 | 1,028 | 1,043 | 900 | 913 | 686 | 695 | 385 | 390 |
| | 45-59 | 627 | 548 | 603 | 526 | 528 | 461 | 402 | 351 | 225 | 197 |
| | 60+ | 436 | 384 | 419 | 369 | 367 | 323 | 279 | 246 | 157 | 138 |
| | Total Respondent Sample Size | | 7,168 | | 6,888 | | 6,029 | | 4,592 | | 2,576 |
| | Total Dialed due to overall RR | | 238,927 | | 229,594 | | 200,972 | | 153,062 | | 85,864 |
| 1.25 | 18-29 | 1,761 | 2,010 | 1,695 | 1,935 | 1,483 | 1,692 | 1,130 | 1,290 | 639 | 729 |
| | 30-44 | 1,338 | 1,357 | 1,287 | 1,306 | 1,126 | 1,142 | 858 | 871 | 485 | 492 |
| | 45-59 | 784 | 685 | 755 | 659 | 660 | 576 | 503 | 439 | 284 | 248 |
| | 60+ | 545 | 480 | 524 | 462 | 458 | 404 | 350 | 308 | 197 | 174 |
| | Total Respondent Sample Size | | 8,960 | | 8,624 | | 7,541 | | 5,749 | | 3,248 |
| | Total Dialed due to overall RR | | 298,658 | | 287,459 | | 251,371 | | 191,639 | | 108,264 |
| 1.75 | 18-29 | 2,466 | 2,815 | 2,371 | 2,706 | 2,077 | 2,371 | 1,585 | 1,809 | 888 | 1,014 |
| | 30-44 | 1,873 | 1,900 | 1,800 | 1,826 | 1,577 | 1,600 | 1,204 | 1,221 | 674 | 684 |
| | 45-59 | 1,098 | 958 | 1,055 | 921 | 924 | 807 | 706 | 616 | 395 | 345 |
| | 60+ | 763 | 672 | 733 | 646 | 642 | 566 | 490 | 432 | 275 | 242 |
| | Total Respondent Sample Size | | 12,544 | | 12,058 | | 10,565 | | 8,064 | | 4,517 |
| | Total Dialed due to overall RR | | 418,122 | | 401,945 | | 352,168 | | 268,793 | | 150,574 |

* Overall response rate in Table 7 refers to the combination of active number rate, response rate, and eligibility rate to be incorporated into the calculations.

Therefore, the total respondent sample size ($n_i$) for this survey would be between 7,168 and 12,544 to estimate a prevalence of 50%, depending on the impact of *Meff*$_S$. After adjusting

for eligibility, response, and active number rates, the number of MPNs needed to be dialed ($n_{MPN}$) to achieve these samples sizes would be between 238,927 and 418,122.

See **Appendix A** for respondent sample size ($n_i$) tables examining the impact of fixed sample sizes on the estimation of $MOE(\hat{P})$ when $Meff_S$ is assumed to be 1.0. **Tables A.1–A.3** examine the impact of the respondent sample sizes ($n_i$) in **Table 7** on the estimation of$MOE(\hat{P})$, while **Tables A.4–A.10** examine other respondent sample sizes ($n_i$).

## 8.3 Contact and Response Rates

Contact, response, and eligibility rates should be computed for the sample using the formulas noted below. Use these formulas so that response rates and eligibility rates can be compared among countries. These rates should be computed for the entire sample and by stratum. The stratification variables might include age group, sex, and any other stratification variables that a country is using in its design (e.g., region).

Note that the required definition of response rates as defined below is consistent with a standard definition of response rates as suggested by the American Association for Public Opinion Research (AAPOR). For the NCD Mobile Phone Survey, we are using the definition of what AAPOR refers to as response rate RR1 in the 2015 version of the AAPOR report (AAPOR, 2015).

These contact and response rates are defined as follows:

$$\mathrm{CON1} = \frac{(\mathrm{I+P})+\mathrm{R}+\mathrm{O}}{(\mathrm{I+P})+\mathrm{R}+\mathrm{O}+\mathrm{NC}+(\mathrm{UH}+\mathrm{UO})} \qquad \text{(Eq. 3)}$$

$$RR1 = \frac{I}{(I+P)+(R+NC+O)+(UH+UO)} \qquad \text{(Eq. 4)}$$

and

$$RR2 = \frac{(I+P)}{(I+P)+(R+NC+O)+(UH+UO)} \qquad \text{(Eq. 5)}$$

Contact Rate 1 (CON1) is the contact rate that assumes all cases of indeterminate eligibility are actually eligible. It is the proportion of all cases in which some respondent was reached by the survey. Response Rate 1 (RR1) is the minimum response rate. It is the number of complete interviews divided by the number of all interviews plus the number of eligible non-interviews plus cases of unknown eligibility. Response Rate 2 (RR2) counts partial interviews as respondents, as well.

In the NCD Mobile Phone Survey, it is impossible to obtain *R* (eligible refusals/break-offs) and *O* (eligible other non-interview) because eligibility should be obtained before those events occur. In the NCD Mobile Phone Survey, eligibility is obtained after these events would occur. As a result, these response rates are reduced to:

$$\mathrm{CON1} = \frac{(\mathrm{I+P})}{(\mathrm{I+P})+\mathrm{NC}+(\mathrm{UH}+\mathrm{UO})} \quad \text{(Eq. 3, reduced)}$$

$$RR1 = \frac{I}{(I+P)+NC+(UH+UO)} \quad \text{(Eq. 4, reduced)}$$

and

$$RR2 = \frac{(I+P)}{(I+P)+NC+(UH+UO)} \quad \text{(Eq. 5, reduced)}$$

For definitions of the *I, P, NC, UH*, and *UO* groupings, refer to **Table 8**.

Note that because of the limitation in determining *R* and *O* from the Eligible, Non-Interview subcategories, CON1 and RR2 are reduced to identical definitions.

One set of operational disposition codes will play a role in computing response rates. One result code will be entered into the database after each attempt to sample an MPN. Once data collection is complete, a final disposition code will be determined for each sampled MPN (see the ***Data Management and Analysis*** for further information about assigning disposition codes). In most instances, the final disposition code will match the result code recorded on the final attempt to complete that part of survey recruitment. The final disposition codes at the individual-levels of effort are defined in **Table 8**.

**Table 8. Final Disposition Codes**

| Final Disposition Codes for RDD Telephone Surveys | Code | Conversion for Mobile Phones |
|---|---|---|
| **1. Interview** | 1.0 | |
| Complete (I) | 1.10 | |
| Partial (P) | 1.20 | Demographic questions completed plus one NCD Question |
| **2. Eligible, Non-Interview** | 2.0 | |
| Non-contact (NC) | 2.20 | Consented and completed Demographic questions but broke off before NCD questions began |
| **3. Unknown Eligibility, Non-Interview** | 3.0 | |
| Unknown if housing unit (UH) | 3.10 | |
| Not attempted or worked | 3.11 | |
| Always busy | 3.12 | Phone busy or network busy/down |
| No answer | 3.13 | |
| Telephone answering device (don't know if housing unit) | 3.14 | Voicemail |
| Telecommunication technological barriers, e.g., call-blocking | 3.15 | Call blocking |
| Technical phone problems | 3.16 | Bad audio quality (i.e., static, poor reception), Unable to connect because of network issues, Breakoff by respondent due to technical difficulties before Demographic questions began |
| *Ambiguous operator's message* | 3.161 | |
| Other (UO) | 3.90 | Breakoff before Demographic questions were complete, Pressed 3 to refuse the interview, Unable to understand language of interview, Immediate hang up, Temporarily out of service, or Part-time fax/data line, Out of coverage area |

| Final Disposition Codes for RDD Telephone Surveys | Code | Conversion for Mobile Phones |
|---|---|---|
| **4. Not Eligible** | 4.0 | |
| Fax/data line | 4.20 | Dedicated fax/data line |
| Nonworking/disconnected number | 4.30 | |
| Nonworking number | 4.31 | |
| Disconnected number | 4.32 | |
| Temporarily out of service | 4.33 | |
| Pagers | 4.44 | |
| Nonresidence | 4.50 | |
| Business, government office, or other organization | 4.51 | |
| Institution | 4.52 | |
| Group quarters | 4.53 | |
| Person not household resident | 4.54 | |
| No eligible respondent | 4.70 | Less than 18 years |
| Quota filled | 4.80 | |
| Other | 4.90 | Phone or SIM (subscriber identity module) card not used |

**Example. Calculating RR1 and RR2**

In this example, we use the number of MPNs needed to dial from **Section 8.2** (i.e., 238,927). If only 20% of the numbers are active, we will reach 47,786 potential respondents. Assuming a 50% eligibility rate (i.e., 23,893 not eligible) and a 30% response rate (16,725 non-interview), we are left with 7,168 respondents. Suppose we have the distribution across the final codes as shown in **Table 9**.

**Table 9. Final Disposition Code Data for Example Survey**

| | Code | No. |
|---|---|---|
| **Interview** | 1.0 | **7,168** |
| Complete (I) | 1.10 | 2,151 |
| Partial (P) | 1.20 | 5,017 |
| **Eligible, Non-Interview** | 2.0 | **4,516** |
| Non-contact (NC) | 2.20 | 4,516 |
| **Unknown Eligibility, Non-Interview** | 3.0 | **12,209** |
| Unknown if Housing Unit (UH) | 3.10 | 1,221 |
| Other (UO) | 3.90 | 10,988 |
| **Not Eligible** | | **23,893** |
| **Total** | | 47,786 |

The response rates would be calculated as follows:

**RR1**

$$RR1 = \frac{I}{(I+P)+NC+(UH+UO)}$$

$$RR1 = \frac{2{,}151}{(2{,}151+5{,}017)+(4{,}516)+(1{,}221+10{,}988)} = 0.09003$$

**RR2/CON1**

$$RR2/CON1 = \frac{(I+P)}{(I+P)+NC+(UH+UO)}$$

$$RR2/CON1 = \frac{2{,}151+5017}{(2{,}151+5{,}017)+(4{,}516)+(1{,}221+10{,}988)} = 0.30$$

## 8.4 Cooperation Rates

In addition to contact, response, and eligibility rates, cooperation rates (COOP) should be computed for the sample using standardized methods so they can be compared across countries. As with response and eligibility rates, cooperation rates should be computed for the entire sample and by strata.

These cooperation rate is defined as follows:

$$COOP = \frac{I+P}{I+P+NC} \qquad \text{(Eq. 6)}$$

COOP is the number of complete and partial interviews divided by the number of all interviews plus the number of eligible non-interviews. The definition of COOP in the NCD Mobile Phone Survey is slightly modified from the definitions suggested by AAPOR because *R* and *O* cannot be determined, however, we can determine other eligible non-interview with *NC* in the NCD Mobile Phone Survey.

Using the example from the previous section, COOP would be calculated as follows:

$$COOP = \frac{I+P}{I+P+NC} = \frac{2{,}151+5{,}017}{2{,}151+5{,}017+4{,}516} = 0.6135$$

# 9. COMPUTING FINAL SAMPLE WEIGHTS

## 9.1 Overview of the Sample Weights (Options 1 and 2 only)

Sample weights are numerical measurements that are essential to producing and evaluating estimates from sample survey data. They are intended to account for the probability that each respondent came into the sample and the differential effects of nonresponse, imperfect sampling frames, and other forces that affect the composition of the sample. Weights for surveys like the NCD Mobile Phone Survey are typically computed in the following five basic steps.

1. **Base Weight.** A base weight is computed for each respondent as the inverse of the (unconditional) probability that the respondent was randomly selected in the sample. This respondent selection probability is in turn determined as the product of the probabilities for the sampling phases that led to selecting the respondent. The probability of selecting a respondent depends on the probability of selecting the respondent's MPN and the probability of selection of that respondent in the second-phase strata (i.e., defined by the respondent's age and sex).

2. **Adjustment for Multiplicity.** Multiplicity occurs when a respondent has a greater probability of selection because the respondent could have been selected more than one time. In this survey, this could occur if a respondent has more than one MPN. The base weight should be adjusted to reflect the increased probability of selection (implies adjustment is <1.00 when respondent uses ≥ 1 MPN). The base weight is multiplied times the inverse of the multiplicity factor.

3. **Adjustment for Multi-user/Clustering.** Clustering occurs when a respondent has a lower probability of selection because one of multiple users of the MPN could have been selected. In this survey, this could occur if a MPN is used by more than one potential eligible respondent. The multiplicity-adjusted weight should be adjusted to reflect the decreased probability of selection as described earlier. This implies adjustment is > 1.00 when the MPN is used by more than one individual who is 18 years and older. The base weight is multiplied by the number in the MPN's cluster of individuals.

4. **Nonresponse Adjustment.** The multiplicity or clustering-adjusted weight is multiplied times the inverse of the individual-level response rates for the selected eligible sample members who are similar to the respondent with respect to characteristics that (hopefully) correlate with key study outcome measurements and the propensity to respond in the survey.

5. **Calibration.** The adjusted weight is then multiplied times a factor that calibrates the sample to the demographic distribution defined by characteristics that are likely to correlate with key study outcomes (e.g., age, sex, and level of education). These calibrated weights become the final adjusted sample weights that should be used for all analyses of the NCD Mobile Phone Survey data in each participating country.

The weighted distribution of the final adjusted weights with respect to the demographic variables used for calibration will thereby match the population counts with respect to these variables.

As noted in **Section 4**, the probability of selection for each stage of the sample design should be retained on the final analytic file for each selected household and individual. These factors should be computed and stored, and the process followed in computing them should be carefully documented at the time that the sample in each stage of selection is chosen.

# REFERENCES

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# APPENDIX A

## A.1. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 7,168

**Total** **7,168**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.47% | 1.57% | 1.95% | 2.09% | 2.24% | 2.39% | 2.39% | 2.56% | 2.44% | 2.61% | 1.47% | 2.61% | |
| 30–44 | 1.78% | 1.80% | 2.38% | 2.40% | 2.73% | 2.75% | 2.91% | 2.94% | 2.97% | 3.00% | 1.78% | 3.00% | |
| 45–59 | 2.51% | 2.35% | 3.35% | 3.13% | 3.84% | 3.59% | 4.10% | 3.83% | 4.19% | 3.91% | 2.35% | 4.19% | |
| 60+ | 3.00% | 2.82% | 4.00% | 3.76% | 4.58% | 4.30% | 4.90% | 4.60% | 5.00% | 4.69% | | | |
| Min | 1.47% | 1.57% | 1.95% | 2.09% | 2.24% | 2.39% | 2.39% | 2.56% | 2.44% | 2.61% | **0.00%** | | **Overall Min** |
| Max | 2.51% | 2.35% | 3.35% | 3.13% | 3.84% | 3.59% | 4.10% | 3.83% | 4.19% | 3.91% | | **4.19%** | **Overall Max** |
| **Summary statements for base sample size of 7,168** | With an overall base sample size of 7,168, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 4.19%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 47,787. If the active number rate is 20%, the number of MPNs that will need to be dialed is 238,935. | | | | | | | | | | | | |

## A.2. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 8,960

**Total** **8,960**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.31% | 1.40% | 1.75% | 1.87% | 2.00% | 2.14% | 2.14% | 2.29% | 2.19% | 2.33% | 1.31% | 2.33% | |
| 30–44 | 1.60% | 1.61% | 2.13% | 2.14% | 2.44% | 2.46% | 2.61% | 2.63% | 2.66% | 2.68% | 1.60% | 2.68% | |
| 45–59 | 2.25% | 2.10% | 3.00% | 2.80% | 3.43% | 3.21% | 3.67% | 3.43% | 3.75% | 3.50% | 2.10% | 3.75% | |
| 60+ | 2.68% | 2.52% | 3.58% | 3.36% | 4.10% | 3.85% | 4.38% | 4.11% | 4.47% | 4.20% | | | |
| Min | 1.31% | 1.40% | 1.75% | 1.87% | 2.00% | 2.14% | 2.14% | 2.29% | 2.19% | 2.33% | **0.00%** | | **Overall Min** |
| Max | 2.25% | 2.10% | 3.00% | 2.80% | 3.43% | 3.21% | 3.67% | 3.43% | 3.75% | 3.50% | | **3.75%** | **Overall Max** |
| **Summary statements for base sample size of 8,960** | With an overall base sample size of 8,960, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 3.75%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 59,734. If the active number rate is 20%, the number of MPNs that will need to be dialed is 298,670. | | | | | | | | | | | | |

## A.3. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 12,544

**Total** **12,544**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.11% | 1.18% | 1.48% | 1.58% | 1.69% | 1.81% | 1.81% | 1.93% | 1.85% | 1.97% | 1.11% | 1.97% | |
| 30–44 | 1.35% | 1.36% | 1.80% | 1.81% | 2.06% | 2.08% | 2.20% | 2.22% | 2.25% | 2.26% | 1.35% | 2.26% | |
| 45–59 | 1.90% | 1.77% | 2.53% | 2.37% | 2.90% | 2.71% | 3.10% | 2.90% | 3.17% | 2.96% | 1.77% | 3.17% | |
| 60+ | 2.27% | 2.13% | 3.02% | 2.84% | 3.46% | 3.25% | 3.70% | 3.48% | 3.78% | 3.55% | | | |
| Min | 1.11% | 1.18% | 1.48% | 1.58% | 1.69% | 1.81% | 1.81% | 1.93% | 1.85% | 1.97% | **0.00%** | | **Overall Min** |
| Max | 1.90% | 1.77% | 2.53% | 2.37% | 2.90% | 2.71% | 3.10% | 2.90% | 3.17% | 2.96% | | **3.17%** | **Overall Max** |
| **Summary statements for base sample size of 12,544** | With an overall base sample size of 12,544, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 3.17%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 83,627. If the active number rate is 20%, the number of MPNs that will need to be dialed is 418,135. | | | | | | | | | | | | |

## A.4. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 5,000

**Total** **5,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.76% | 1.88% | 2.34% | 2.50% | 2.68% | 2.86% | 2.87% | 3.06% | 2.93% | 3.13% | 1.76% | 3.13% | |
| 30–44 | 2.14% | 2.15% | 2.85% | 2.87% | 3.26% | 3.29% | 3.49% | 3.51% | 3.56% | 3.59% | 2.14% | 3.59% | |
| 45–59 | 3.01% | 2.81% | 4.01% | 3.75% | 4.60% | 4.29% | 4.91% | 4.59% | 5.01% | 4.69% | 2.81% | 5.01% | |
| 60+ | 3.59% | 3.37% | 4.79% | 4.50% | 5.49% | 5.15% | 5.87% | 5.51% | 5.99% | 5.62% | | | |
| Min | 1.76% | 1.88% | 2.34% | 2.50% | 2.68% | 2.86% | 2.87% | 3.06% | 2.93% | 3.13% | **0.00%** | | **Overall Min** |
| Max | 3.01% | 2.81% | 4.01% | 3.75% | 4.60% | 4.29% | 4.91% | 4.59% | 5.01% | 4.69% | | **5.01%** | **Overall Max** |
| **Summary statements for base sample size of 5,000** | With an overall base sample size of 5,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 5.01%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 33,334. If the active number rate is 20%, the number of MPNs that will need to be dialed is 166,670. | | | | | | | | | | | | |

## A.5. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 7,000

**Total** **7,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.48% | 1.59% | 1.98% | 2.11% | 2.27% | 2.42% | 2.42% | 2.59% | 2.47% | 2.64% | 1.48% | 2.64% | |
| 30–44 | 1.81% | 1.82% | 2.41% | 2.43% | 2.76% | 2.78% | 2.95% | 2.97% | 3.01% | 3.03% | 1.81% | 3.03% | |
| 45–59 | 2.54% | 2.38% | 3.39% | 3.17% | 3.88% | 3.63% | 4.15% | 3.88% | 4.24% | 3.96% | 2.38% | 4.24% | |
| 60+ | 3.04% | 2.85% | 4.05% | 3.80% | 4.64% | 4.35% | 4.96% | 4.65% | 5.06% | 4.75% | | | |
| Min | 1.48% | 1.59% | 1.98% | 2.11% | 2.27% | 2.42% | 2.42% | 2.59% | 2.47% | 2.64% | **0.00%** | | **Overall Min** |
| Max | 2.54% | 2.38% | 3.39% | 3.17% | 3.88% | 3.63% | 4.15% | 3.88% | 4.24% | 3.96% | | **4.24%** | **Overall Max** |
| **Summary statements for base sample size of 7,000** | With an overall base sample size of 7,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 4.24%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 46,667. If the active number rate is 20%, the number of MPNs that will need to be dialed is 233,335. | | | | | | | | | | | | |

## A.6. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 10,000

**Total** **10,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.24% | 1.33% | 1.66% | 1.77% | 1.90% | 2.03% | 2.03% | 2.17% | 2.07% | 2.21% | 1.24% | 2.21% | |
| 30–44 | 1.51% | 1.52% | 2.01% | 2.03% | 2.31% | 2.32% | 2.47% | 2.49% | 2.52% | 2.54% | 1.51% | 2.54% | |
| 45–59 | 2.13% | 1.99% | 2.84% | 2.65% | 3.25% | 3.04% | 3.47% | 3.25% | 3.55% | 3.31% | 1.99% | 3.55% | |
| 60+ | 2.54% | 2.38% | 3.39% | 3.18% | 3.88% | 3.64% | 4.15% | 3.89% | 4.23% | 3.97% | | | |
| Min | 1.24% | 1.33% | 1.66% | 1.77% | 1.90% | 2.03% | 2.03% | 2.17% | 2.07% | 2.21% | **0.00%** | | **Overall Min** |
| Max | 2.13% | 1.99% | 2.84% | 2.65% | 3.25% | 3.04% | 3.47% | 3.25% | 3.55% | 3.31% | | **3.55%** | **Overall Max** |
| **Summary statements for base sample size of 10,000** | With an overall base sample size of 10,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 3.55%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 66,667. If the active number rate is 20%, the number of MPNs that will need to be dialed is 333,335. | | | | | | | | | | | | |

## A.7. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 15,000

**Total** **15,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 1.01% | 1.08% | 1.35% | 1.44% | 1.55% | 1.65% | 1.66% | 1.77% | 1.69% | 1.80% | 1.01% | 1.80% | |
| 30–44 | 1.23% | 1.24% | 1.64% | 1.66% | 1.88% | 1.90% | 2.01% | 2.03% | 2.06% | 2.07% | 1.23% | 2.07% | |
| 45–59 | 1.74% | 1.62% | 2.32% | 2.16% | 2.65% | 2.48% | 2.84% | 2.65% | 2.89% | 2.71% | 1.62% | 2.89% | |
| 60+ | 2.07% | 1.95% | 2.77% | 2.60% | 3.17% | 2.97% | 3.39% | 3.18% | 3.46% | 3.25% | | | |
| Min | 1.01% | 1.08% | 1.35% | 1.44% | 1.55% | 1.65% | 1.66% | 1.77% | 1.69% | 1.80% | **0.00%** | | **Overall Min** |
| Max | 1.74% | 1.62% | 2.32% | 2.16% | 2.65% | 2.48% | 2.84% | 2.65% | 2.89% | 2.71% | | **2.89%** | **Overall Max** |
| **Summary statements for base sample size of 15,000** | With an overall base sample size of 15,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 2.89%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 100,000. If the active number rate is 20%, the number of MPNs that will need to be dialed is 500,000. | | | | | | | | | | | | |

## A.8. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 20,000

**Total** **20,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 0.88% | 0.94% | 1.17% | 1.25% | 1.34% | 1.43% | 1.43% | 1.53% | 1.46% | 1.56% | 0.88% | 1.56% | |
| 30–44 | 1.07% | 1.08% | 1.42% | 1.43% | 1.63% | 1.64% | 1.74% | 1.76% | 1.78% | 1.79% | 1.07% | 1.79% | |
| 45–59 | 1.50% | 1.41% | 2.01% | 1.87% | 2.30% | 2.15% | 2.46% | 2.30% | 2.51% | 2.34% | 1.41% | 2.51% | |
| 60+ | 1.80% | 1.69% | 2.40% | 2.25% | 2.74% | 2.58% | 2.93% | 2.75% | 2.99% | 2.81% | | | |
| Min | 0.88% | 0.94% | 1.17% | 1.25% | 1.34% | 1.43% | 1.43% | 1.53% | 1.46% | 1.56% | **0.00%** | | **Overall Min** |
| Max | 1.50% | 1.41% | 2.01% | 1.87% | 2.30% | 2.15% | 2.46% | 2.30% | 2.51% | 2.34% | | **2.51%** | **Overall Max** |
| **Summary statements for base sample size of 20,000** | With an overall base sample size of 20,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 2.51%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 133,334. If the active number rate is 20%, the number of MPNs that will need to be dialed is 666,670. | | | | | | | | | | | | |

## A.9. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 25,000

**Total** **25,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 0.79% | 0.84% | 1.05% | 1.12% | 1.20% | 1.28% | 1.28% | 1.37% | 1.31% | 1.40% | 0.79% | 1.40% | |
| 30–44 | 0.96% | 0.96% | 1.27% | 1.28% | 1.46% | 1.47% | 1.56% | 1.57% | 1.59% | 1.60% | 0.96% | 1.60% | |
| 45–59 | 1.35% | 1.26% | 1.79% | 1.68% | 2.06% | 1.92% | 2.20% | 2.05% | 2.24% | 2.10% | 1.26% | 2.24% | |
| 60+ | 1.61% | 1.51% | 2.14% | 2.01% | 2.45% | 2.30% | 2.62% | 2.46% | 2.68% | 2.51% | | | |
| Min | 0.79% | 0.84% | 1.05% | 1.12% | 1.20% | 1.28% | 1.28% | 1.37% | 1.31% | 1.40% | **0.00%** | | **Overall Min** |
| Max | 1.35% | 1.26% | 1.79% | 1.68% | 2.06% | 1.92% | 2.20% | 2.05% | 2.24% | 2.10% | | **2.24%** | **Overall Max** |
| **Summary statements for base sample size of 25,000** | With an overall base sample size of 25,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 2.24%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 166,667. If the active number rate is 20%, the number of MPNs that will need to be dialed is 833,335. | | | | | | | | | | | | |

## A.10. Analysis of Stratum-level $MOE(\hat{P})$ when respondent sample size is 30,000

**Total 30,000**

| | Sex by Prevalence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.1** | | **0.2** | | **0.3** | | **0.4** | | **0.5** | | | | |
| **Age** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Min** | **Max** | |
| 18–29 | 0.72% | 0.77% | 0.96% | 1.02% | 1.09% | 1.17% | 1.17% | 1.25% | 1.19% | 1.28% | 0.72% | 1.28% | |
| 30–44 | 0.87% | 0.88% | 1.16% | 1.17% | 1.33% | 1.34% | 1.42% | 1.43% | 1.45% | 1.46% | 0.87% | 1.46% | |
| 45–59 | 1.23% | 1.15% | 1.64% | 1.53% | 1.88% | 1.75% | 2.01% | 1.87% | 2.05% | 1.91% | 1.15% | 2.05% | |
| 60+ | 1.47% | 1.38% | 1.96% | 1.84% | 2.24% | 2.10% | 2.40% | 2.25% | 2.44% | 2.29% | | | |
| Min | 0.72% | 0.77% | 0.96% | 1.02% | 1.09% | 1.17% | 1.17% | 1.25% | 1.19% | 1.28% | **0.00%** | | **Overall Min** |
| Max | 1.23% | 1.15% | 1.64% | 1.53% | 1.88% | 1.75% | 2.01% | 1.87% | 2.05% | 1.91% | | **2.05%** | **Overall Max** |
| **Summary statements for base sample size of 30,000** | With an overall base sample size of 30,000, the maximum $MOE(\hat{P})$ we will see estimating prevalences from 10% to 50% for each of four age and two sex categories is 2.05%. Assuming eligibility rates of 50% and response rates of 30%, the effective sample size is 200,000. If the active number rate is 20%, the number of MPNs that will need to be dialed is 1,000,000. | | | | | | | | | | | | |

## A.11 Customizable Parameters for Sample Size Analysis

| Parameter | Code |
|---|---|
| Active Number Rate | ANR |
| Eligibility Rate | ER |
| Response Rate | RR |
| Margin of Error | $MOE(\hat{P})$ |
| Prevalence | P |
| Stratification Classes | Strata |
| Stratum-level Misspecification Effect | $Meff_S$ |
| Distribution of General Population across Strata | Proportions |
| Total Sample Size | Total_n |