2010 NATIONAL SURVEY ON DRUG USE AND HEALTH

STATISTICAL INFERENCE REPORT

Prepared for the 2010 Methodological Resource Book

Contract Nos. HHSS283200800004C and HHSS283201000003C
RTI Project Nos. 0211838.108.001.002 and 0212800.002.120.008.007.006
Deliverable No. 39

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Section

1. Introduction

Statistical inference occurs whenever data obtained from sample observations belonging to and considered representative of a larger target population are used to make generalizations concerning the larger population. The target population for the 2010 National Survey on Drug Use and Health (NSDUH)[1] was the U.S. civilian, noninstitutionalized population aged 12 or older (at the time of their interview) in 2010. Measurements for this target population were the responses to the survey questions provided by persons participating in the 2010 survey.

Statistical inferences concerning characteristics of interest for this population and various subpopulations are presented in the form of estimates derived from the sample data collected. Examples of the inferences made from the 2010 NSDUH data are presented in the 2010 detailed tables (Center for Behavioral Health Statistics and Quality [CBHSQ], 2011a) and the 2010 summary of national findings report (CBHSQ, 2011c)[2] and include estimates of the number of persons who were substance users during the past month, past year, and their lifetime, as well as the associated percentages (prevalence rates) of substance use for these reference periods. Inferences also were made for such categories as substance initiation; risk and protective factors; substance dependence, dependence or abuse, and treatment. Estimates of measures related to mental health problems are presented in the 2010 mental health detailed tables (CBHSQ, 2012a) and the 2010 mental health findings report (CBHSQ, 2012b).

The focus of this report is to describe the statistical inference procedures used to produce design-based estimates as presented in the 2010 detailed tables, the 2010 mental health detailed tables, the 2010 national findings report, and the 2010 mental health findings report.[3] The statistical procedures and information found in this report can also be generally applied to analyses based on the public use file. This report is organized as follows: Section 2 provides background information concerning the 2010 NSDUH; Section 3 discusses the prevalence rates and how they were calculated; Section 4 briefly discusses how missing item responses of variables that are not imputed may lead to biased estimates; Section 5 discusses sampling errors and how they were calculated; Section 6 describes the degrees of freedom that were used when comparing estimates; and Section 7 discusses how the statistical significance of differences between estimates was determined. Section 8 discusses confidence interval estimation, and Section 9 describes how past year incidence of drug use was computed. Finally, Section 10 discusses the conditions under which estimates with low precision were suppressed. Appendix A contains examples that demonstrate how to conduct various statistical procedures documented within this report using SAS® and SUDAAN® Software for Statistical Analysis of Correlated Data (RTI International, 2008).

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[1] Prior to 2002, the survey was called the National Household Survey on Drug Abuse (NHSDA).

[2] See http://www.samhsa.gov/data/NSDUH.aspx.

[3] Inconsistencies may be found by users of the 2010 public use file in the variable names referenced in this report, the information presented in Table 1 in Section 5, and other specific numbers presented in this report (i.e., degrees of freedom). The specific information referenced in this report is based on the restricted-use dataset that was used to create the 2010 detailed tables (CBHSQ, 2011b), the 2010 mental health detailed tables (CBHSQ, 2012a), the 2010 national findings report (CBHSQ, 2011c), and the 2010 mental health findings report (CBHSQ, 2012b).

2. Background

The 2010 National Survey on Drug Use and Health (NSDUH)[4] is an extension of a coordinated 5-year sample design providing estimates for all 50 States plus the District of Columbia for the years 2005 through 2009, then continuing through 2011. The survey is conducted using computer-assisted interviewing (CAI) methods for the screening and interviewing of selected respondents. The respondent universe is the civilian, noninstitutionalized population aged 12 years old or older residing within the United States and the District of Columbia. Persons excluded from the universe include active-duty military personnel, persons with no fixed household address (e.g., homeless and/or transient persons not in shelters), and residents of institutional group quarters, such as correctional facilities, nursing homes, mental institutions, and long-term hospitals.

The coordinated design for 2005 through 2009 facilitated a 50 percent overlap in second-stage units (area segments) within each successive 2-year period from 2005 through 2009. The 2010 and 2011 NSDUHs continue the 50 percent overlap by retaining half of the second-stage units from the previous year. The remainder of the sample was drawn from the 2005 through 2009 reserve sample, which consisted of area segments that were not used in previous years but were reserved for potential supplemental samples or field testing. Because the coordinated design enables estimates to be developed by State in all 50 States plus the District of Columbia, States may be viewed as the first level of stratification as well as a reporting variable.

For the 50-State design, 8 States were designated as large sample States (California, Florida, Illinois, Michigan, New York, Ohio, Pennsylvania, and Texas). In 2010, sample sizes in these States ranged from 2,985 to 3,590 respondents. For the remaining 42 States and the District of Columbia, sample sizes ranged from 868 to 974. State estimates combining multiple years of data and using either small area estimation (SAE)[5] or direct estimation have been tabulated.

States were first stratified into a total of 900 State sampling regions (SSRs) (48 regions in each large sample State and 12 regions in each small sample State). These regions were contiguous geographic areas designed to yield on average the same number of interviews.[6] Unlike the 1999 through 2001 NHSDAs and the 2002 through 2004 NSDUHs in which the first-stage sampling units were clusters of census blocks called area segments, the first stage of selection for the 2005 through 2011 surveys was census tracts.[7] This stage was included to contain sample segments within a single census tract to the extent possible.[8]

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[4] Prior to 2002, the survey was called the National Household Survey on Drug Abuse (NHSDA).

[5] SAE is a hierarchical Bayes modeling technique used to produce State-level estimates for a selected number of measures. For more details, see the *State Estimates of Substance Use and Mental Disorders from the 2008-2009 National Surveys on Drug Use and Health* (Hughes, Muhuri, Sathe, & Spagnola, 2011).

[6] Areas were defined using 2000 census geography. Dwelling units (DUs) and population counts were obtained from the 2000 census data supplemented with revised population counts from Claritas. Claritas Inc., is a market research firm headquartered in San Diego, California (see http://www.nielsen.com/us/en.html).

[7] Census tracts are relatively permanent statistical subdivisions of counties and provide a stable set of geographic units across decennial census periods.

[8] Some census tracts had to be aggregated in order to meet the minimum DU requirement of 150 DUs in urban areas and 100 DUs in rural areas.

A total of 48 census tracts per SSR were selected, and within these sampled census tracts, adjacent census blocks were combined to form the second-stage sampling units or area segments. Although only 24 segments were needed to support the coordinated 5-year sample, an additional 24 segments were selected to support any supplemental studies that the Substance Abuse and Mental Health Services Administration (SAMHSA) may choose to field. These 24 segments constitute the reserve sample and were available for use in 2010. Eight sample segments per SSR were fielded during the 2010 survey year. Four of these segments were retained from the 2009 survey, and four were selected from the reserve sample. An additional four reserve segments per SSR were selected for use in the 2011 survey. These sampled segments were allocated equally into four separate samples, one for each 3-month period (calendar quarter) during the year, so that the survey was essentially continuous in the field.

The process by which the DU frame is constructed is called "counting and listing." In summary, a certified lister visits the selected segment and lists a detailed and accurate address (or description, if no address is available) for each DU within the segment boundaries. Sometimes the number of DUs in a sampled segment substantially exceeds the specified maximum of 400. In these cases, the segment is partitioned into smaller pieces or subsegments, and one is randomly selected for listing. Starting with the 2008 NSDUH, large segments that could be subdivided based on census information were subsegmented in-house prior to being sent to the field for listing. In a few of these cases, additional subsegmenting was required for one of the following reasons: (1) the segment experienced high growth and the census counts used in the initial subsegment were outdated, or (2) there was not enough information available during the first subsegmentation, and the initial subsegment was still too large to list. In these cases, the initial subsegment was created to make the counting more manageable, but a second subsegment had to be created to make listing feasible. All of the second subsegmentation occurred in urban areas for the 2008 through 2010 surveys.

The occasional second subsegmentation was inadvertently omitted during the weighting process for the 2008 through 2010 surveys. Altogether, there were 66 affected interview cases in 2008, 144 affected cases in 2009, and 154 affected cases in 2010. An assessment of the impact of the missing second subsegmenting factor on NSDUH results was conducted for the 2008 through 2010 surveys. Simplified adjusted weights were created by multiplying the missing second subsegmenting factor by the analysis weight and poststratifying this weight to the census control totals. These adjusted weights were then used in an analysis of key drug and mental health measures, and the results were compared with results from the same analysis that used the standard analysis weight. Although the differences for totals were more noticeable than the differences for prevalence rates, the significance results were similar. Because the groups compared contained the same respondents, the comparisons had the power to declare very small differences as significant. Therefore, it was determined that the missing second subsegmenting factor in the standard analysis weight had minimal impact on the selected outcome measures in the 2008 through 2010 NSDUHs.

The overall design remained the same beginning with the 2002 NSDUH and continuing through the 2010 NSDUH. Survey respondents were given a $30 incentive payment for participation, which increased response rates, thereby requiring fewer selected households than in previous surveys. Also, a pair-sampling strategy was implemented that increased the number of pairs selected in DUs with older persons on the roster (Chromy & Penne, 2002).

As was done in the 2008 and 2009 NSDUHs, a Mental Health Surveillance Study (MHSS) was embedded in the 2010 NSDUH. Each respondent in a subsample of about 500 adults (in 2008, the subsample was about 1,500, and in 2009, the subsample was about 500) who had completed the NSDUH interview was administered the Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Non-patient Edition (SCID-I/NP) (First, Spitzer, Gibbon, & Williams, 2002).[9] The SCID was adapted for this study and was administered via paper and pencil over the telephone approximately 2 to 4 weeks after the NSDUH interview. In 2008, a split-sample MHSS was conducted to develop models using the SCID data that would use the Kessler-6 (K6) nonspecific psychological distress scale and two competing functional impairment scales in order to generate prevalence estimates of serious mental illness (SMI) among adults aged 18 or older for the entire sample. Based on the results from the 2008 MHSS, a modified World Health Organization Disability Assessment Schedule (WHODAS) (Rehm et al., 1999) was adopted for the 2009 and 2010 surveys. As with the 2009 MHSS, the purpose of the 2010 MHSS was to monitor the efficacy of the selected screening measure. For more information about the MHSS sample design, see the Sample Design Report in the *2010 NSDUH Methodological Resource Book* (Morton, Martin, Chromy, Hirsch, & Ridenhour, 2011).

The final respondent sample of 67,804 persons for the 2010 NSDUH provides a sufficient sample to create domain estimates for a broad range of ages and other demographic categories. Individual observations are weighted in a manner such that the weighted sample is representative of the civilian, noninstitutionalized population aged 12 or older for the general U.S. population and for each of the individual States. The person-level weights in NSDUH are calibrated to population estimates (or control totals) obtained from the U.S. Census Bureau. For more information on the sampling weight calibration in the 2010 NSDUH, see the Person-Level Sampling Weight Calibration report in the *2010 NSDUH Methodological Resource Book* (Chen et al., 2012).

[9] "DSM-IV-TR" stands for the *Diagnostic and Statistical Manual of Mental Disorders, 4th ed., Text Revision* (American Psychiatric Association, 2008).

3. Prevalence Rates

The national prevalence rates were computed using a multiprocedure package called SUDAAN® Software for Statistical Analysis of Correlated Data (RTI International, 2008). The final, nonresponse-adjusted, and poststratified analysis weights were used in SUDAAN to compute unbiased design-based drug use estimates. Appendix A contains an example that demonstrates how to compute the prevalence rates using SUDAAN procedures as defined below.

Prevalence rates are the proportions of the population who exhibit characteristics of interest (such as substance use). Let $\hat{p}_d$ represent the prevalence rate of interest for domain *d*. Then $\hat{p}_d$ would be defined as the ratio

$$\hat{p}_d = \frac{\hat{Y}_d}{\hat{N}_d},$$

where $\hat{Y}_d = \sum_{i \in S} w_i \delta_i y_i$ represents the estimated number of persons exhibiting the characteristic of interest in domain *d*, $\hat{N}_d = \sum_{i \in S} w_i \delta_i$ represents the estimated population total for domain *d*, *S* represents the sample, w_i represents the analysis weight, δ_i represents an indicator variable that is defined as 1 if the *i*th sample unit is in domain *d* and is equal to 0 otherwise, and y_i represents an indicator variable that is defined as 1 if the *i*th sample unit exhibits the characteristic of interest and is equal to 0 otherwise.

For certain populations of interest, sample sizes may not be adequate to support inferences using only 1 year of survey data. In these cases, estimates were produced from annual averages based on combined data from 2 or more survey years, and they are clearly labeled in the detailed tables. The data were combined for the 2007-2008, 2009-2010, or 2007-2010 surveys to obtain annual averages, then the prevalence rates were computed in SUDAAN as described above. The annual averages were derived by concatenating the data for the respective years and dividing the analysis weights by a factor that varied depending on the number of years of concatenated data. The weight was divided by a factor of 2 for 2 years of concatenated data and a factor of 4 for 4 years of concatenated data.

3.1 Mental Illness

Estimates of serious mental illness (SMI) and any mental illness (AMI) were derived from responses to the National Survey on Drug Use and Health (NSDUH) adult mental health items that assessed impairment (these questions were added to the mental health module in 2008) and items that assessed psychological distress (the Kessler-6 [K6] scale was modified in the 2008 mental health module; see Section 3.3 for more details). For adults aged 18 or older, a split-sample study was embedded within the 2008 NSDUH, in which a random half of the adult NSDUH main sample received an abbreviated version of the World Health Organization Disability Assessment Schedule (WHODAS) and the other half received the Sheehan Disability

Scale (SDS). The WHODAS questions were retained for use in the 2009 NSDUH and future surveys.

In addition, the Mental Health Surveillance Study (MHSS) was initiated in 2008 in which a standard clinical interview by mental health clinicians was administered to a subsample of adults who had completed the NSDUH interview to determine their mental health status. The randomization of the WHODAS and SDS impairment scales was maintained within this clinical interview subsample so that about half of the MHSS sample participants were administered the WHODAS and half were administered the SDS. Mental illness was measured using an adapted version of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Non-patient Edition (SCID-I/NP) (First et al., 2002), and the Global Assessment of Functioning (GAF) scale[10] (Endicott, Spitzer, Fleiss, & Cohen, 1976) was used to measure the associated level of impairment. The SCID and the GAF together were used to construct "gold-standard" measures of mental illness. A statistical model was developed that used the SCID-based (i.e., gold-standard) SMI status from the clinical interviews as a dependent variable and the short scales (the K6 in combination with the WHODAS) as independent variables. Once the model was estimated, the predicted probability of having SMI for each respondent was calculated, and an optimal cut point was identified that approximately equalized the weighted number of false positives and false negatives by comparing SCID-based SMI estimates with those derived from the model and cut point (i.e., predicted probabilities at or above the cut point were coded as SMI positive; otherwise, they were coded as SMI negative). For more information on the MHSS analysis, see Appendix B in the 2009 and 2010 mental health findings reports (Center for Behavioral Health Statistics and Quality [CBHSQ], 2010b, 2012b). Because an important objective of the MHSS was to determine whether true differences in estimates of SMI existed among the 2008 through 2010 surveys, the decision was made to use the same mental illness prediction model (described below) from 2008 to produce estimates of SMI in the 2009 and 2010 NSDUHs.

The prediction model is a weighted logistic regression. With SMI status based on having a SCID diagnosis plus a GAF score less than or equal to 50, the response variable Y was defined so that $Y = 1$ when an SMI diagnosis is positive; otherwise, $Y = 0$. If $\mathbf{x}$ is a vector of realized explanatory variables, then the response probability $\pi = \Pr(Y = 1 | \mathbf{x})$ can be estimated using a weighted logistic regression model. The final 2008 WHODAS calibration model was determined as follows:

$$\text{logit}(\hat{\pi}) \equiv \log\left[\hat{\pi}/(1-\hat{\pi})\right] = -4.74999920 + 0.20977232x_k + 0.38388395x_w,$$

where $\hat{\pi}$ refers to an estimate of the SMI response probability π,

[10] The GAF is a numeric scale (0 through 100) used to subjectively rate the social, occupational, and psychological functioning of adults and is described in the DSM-IV-TR (American Psychiatric Association, 2008, p. 32). Lower scores represent higher levels of functional impairment. Descriptions of impairment are provided at 10-point intervals, such as 1 to 10, 11 to 20, and so on up to 91 to 100. For example, a GAF score between 51 and 60 is described as having moderate symptoms of impairment, while a score higher than 60 represents several categories of impairment ranging from none to slight, and a score lower than 51 represents several categories ranging from serious to extreme.

$$x_k = \begin{cases} 0, \text{ if worst K6 total score} < 8 \\ \text{worst K6 total score minus 7, otherwise} \end{cases}$$

the worst K6 total score is the maximum of past month and past year total scores, $x_w =$ sum of recoded WHODAS item scores (where item scores of 0 or 1 were recoded as 0), and item scores of 2 or 3 were recoded as 1. Rearranging terms provided a direct calculation of the *predicted probability* of SMI:

$$\hat{\pi} = \frac{1}{1+\exp[-(-4.74999920+0.20977232x_k+0.38388395x_w)]}.$$

$$\hat{\pi} = \frac{1}{1+\exp[-(-4.7500+0.2098X_k+0.3839X_w)]}.$$

Next, a cut point probability π_0 was determined so that if $\hat{\pi} \geq \pi_0$ for a particular respondent, then he or she was *predicted* to be SMI positive; otherwise, he or she was predicted to be SMI negative. Receiver operating characteristic (ROC) analyses were used to determine the cut point that resulted in the weighted number of false-positive and false-negative counts being (approximately) equal, thus ensuring (approximately) unbiased estimates. The optimal cut point was determined to be 0.26971946. See Aldworth et al. (2009) for further details.

The standard errors (SEs) that have been calculated for the prevalence estimates of adult mental illness are based on the assumption that the prediction model used for producing these estimates is correct and the estimated parameters from the prediction model are the "true" parameters. Thus, the SMI and other mental illness estimates and SEs were calculated similarly to other 0/1 variables (for more details on calculating SEs, see Section 5). The current calculation of the SEs does not take into account the variability incurred by using a small sample-based model to calculate predicted values, which then are used to produce estimates of mental illness. A study is currently under way to assess the impact on SEs of using a small sample-based model to estimate mental illness prevalence.

In the 2010 mental health detailed tables (CBHSQ, 2012a), the 2009 and 2010 prevalence rates for SMI and any other mental illness category (any, moderate, serious or moderate, or mild mental illness) were computed using the standard analysis weight (ANALWT). However, for 2008 prevalence rates, ANALWT should be used only for SMI. For all other mental illness variables (i.e., any, moderate, serious or moderate, or mild mental illness), the split-sample weight (MHSAMPWT) in conjunction with the sample indicator that subsets to the 2008 WHODAS half-sample data (MHSAMP08=1) should be used so that only sample A data are used in the estimation of these variables. This is because the 2008 SMI estimates are based on both the WHODAS and SDS half samples, whereas estimates of other mental health categories are based only on the WHODAS half sample. For more details, see Section B.4.3 in Appendix B of the 2009 mental health findings report (CBHSQ, 2010b).

3.2 Adult Major Depressive Episode (MDE)

The past year adult major depressive episode (MDE) estimates shown in the 2010 mental health detailed tables (CBHSQ, 2012a) are based on the full sample. This differs from the 2008 past year MDE estimates shown in both the 2008 detailed tables (Office of Applied Studies [OAS], 2009a) and the 2009 mental health detailed tables (CBHSQ, 2010a), which were based only on the sample of adult respondents who received the WHODAS questions in the mental health questionnaire module that preceded the adult depression questionnaire module. The analysis of 2008 MDE data was restricted to only the WHODAS half sample because of apparent reporting differences (context effects) between the half sample that was administered the WHODAS and the other half sample of adult respondents who received the SDS questions (Dean & LeBaron, 2009). Both half samples have issues with context effects not seen in 2007 and previous years because of the revisions to the mental health module preceding the adult depression module. To address the break in comparability of the adult MDE data beginning in 2008 and to estimate adult MDE based on the full sample of adults from 2008, adjusted versions of lifetime and past year MDE variables for adults were created retroactively for 2005 to 2008. These variables were adjusted to make MDE estimates from the SDS half sample in 2008 and from all adult respondents for 2005 to 2007 comparable with the MDE estimates based on data from the half sample that received the WHODAS in 2008 and from all adult respondents in later years (2009 onward). The adjusted data from 2005 to 2008 can be used in conjunction with unadjusted data from later years to estimate trends in adult MDE over the entire period from 2005 to 2010.

In the 2010 mental health detailed tables (CBHSQ, 2012a), the standard analysis weight (ANALWT) was used to generate all estimates of adult MDE. More information about how the statistically adjusted adult MDE variables were created can be found in Section B.4.4 in Appendix B of the 2010 mental health findings report (CBHSQ, 2012b) and in the report describing the adjustments (Aldworth, Kott, Yu, Mosquin, & Barnett-Walker, 2012).

3.3 Serious Psychological Distress (SPD)

The K6 scale, a measure of psychological distress, was used to create the variable serious psychological distress (SPD). Prior to 2008, the K6 consisted of one set of questions that asked adult respondents about symptoms of psychological distress in the month when they were the most depressed, anxious, or emotionally distressed in the past year. Starting in 2008, the K6 consisted of two sets of questions that asked adult respondents how frequently they experienced symptoms of psychological distress during two different time periods: (1) during the past 30 days, and (2) if applicable, the month in the past year when they were at their worst emotionally. Respondents were asked about this second time period only if they indicated that there was a month in the past 12 months when they felt more depressed, anxious, or emotionally stressed than they felt during the past 30 days. Because of this change, past year K6 and SPD estimates from years prior to 2008 were no longer comparable with estimates from 2008 onward. To address this comparability issue, adjusted versions of the past year worst K6 total score and past year SPD variables were created for each of the years from 2005 to 2007 to make the 2005 to 2007 past year K6 scores and past year SPD estimates comparable with their 2008 to 2010 counterparts.

In the 2010 mental health detailed tables (CBHSQ, 2012a), the standard analysis weight (ANALWT) was used to generate 2005 through 2010 estimates of past year SPD as well as estimates of past month SPD for 2009 and 2010. The 2010 mental health findings report (CBHSQ, 2012b) did not present SPD estimates. More information about how the adjusted K6 and SPD variables were created can be found in the report describing these adjustments (Aldworth et al., 2012).

3.4 Revised Estimates for 2006 to 2010

During regular data collection and processing checks for the 2011 NSDUH, data errors were identified. These errors affected the data for Pennsylvania (2006-2010) and Maryland (2008-2009). Cases with erroneous data were removed from the data files, and the remaining cases were reweighted to provide representative estimates. The errors had minimal impact on the national estimates and no effect on direct estimates for the other 48 States and the District of Columbia. In reports where model-based small area estimation techniques are used, estimates for all States may be affected, even though the errors were concentrated in only two States.
In reports that do not use model-based estimates, the only estimates appreciably affected are estimates for Pennsylvania, Maryland, the mid-Atlantic division, and the Northeast region.
The 2010 detailed tables (CBHSQ, 2011b), the 2010 mental health detailed tables (CBHSQ, 2012a), the 2010 mental health findings report (CBHSQ, 2012b), and the 2010 national findings report (CBHSQ, 2011c) do not include State-level or model-based estimates. However, they do include estimates for the mid-Atlantic division and the Northeast region. Estimates based on 2006-2010 data may differ from estimates published in the 2011 detailed tables and later. Thus, tables containing estimates from these geographic regions have been revised using the corrected data, and a note has been added to the revised tables to indicate this to the user. Because only a limited set of tables use revised data, there exist some minor differences in the marginal estimates (i.e., the estimates in the row described as "TOTAL" between the revised and the nonrevised tables).

Caution is advised when comparing data from older reports with data from more recent reports that are based on corrected data files. As discussed above, comparisons of estimates for Pennsylvania, Maryland, the mid-Atlantic division, and the Northeast region are of most concern, while comparisons of national data or data for other States and regions are essentially still valid. A selected set of corrected versions of reports and tables have been produced.
In particular, a set of modified detailed tables that include revised 2006-2010 estimates for the mid-Atlantic division and the Northeast region for certain key measures have been released.
Given the change noted above, comparisons between unrevised 2006-2010 estimates and estimates based on revised 2010 data for the areas of most concern are not recommended.

3.5 Revised Adult Mental Illness Estimates for 2008 to 2011

The Substance Abuse and Mental Health Services Administration (SAMHSA) has been publishing estimates of the prevalence of past year SMI and AMI among adults aged 18 or older since the release of the 2008 NSDUH national findings report (OAS, 2009b). Estimates were based on a model developed in 2008. In 2013, SAMHSA developed a more accurate model for the 2012 data. This revised model incorporates the NSDUH respondent's age and indicators of past year suicide thoughts and depression, along with the variables that were specified in the

2008 model (K6 and WHODAS), leading to more accurate estimates of SMI and AMI. Estimates and estimation procedures described in this report for those measures are based on the 2008 model and not the 2012 revised model. Other mental illness measures, such as MDE, SPD, and serious thoughts of suicide, were not affected. For further information on the revised model, see the NSDUH short report titled *Revised Estimates of Mental Illness from the National Survey on Drug Use and Health* at http://samhsa.gov/data/default.aspx.

4. Missingness

4.1 Potential Estimation Bias Due to Missingness

In the 2010 National Survey on Drug Use and Health (NSDUH), many variables, including core drug and demographic variables, had missing item response values imputed. See the 2010 NSDUH imputation report (Frechtel et al., 2012) for further details. However, the missing item responses of many other variables were not imputed, and these missing responses may lead to biased estimates in the 2010 detailed tables (Center for Behavioral Health Statistics and Quality [CBHSQ], 2011a) and the 2010 mental health detailed tables (CBHSQ, 2012a).[11] In addition, another source of potential uncertainty about some estimates may occur due to the way unknown item responses (e.g., blank, "don't know," "refused") were actually coded for different variables. For example, some recoded variables (i.e., variables created from one or more source variables) classified unknown item responses in the source variable(s) as missing values, whereas others did not. See Ruppenkamp, Emrich, Aldworth, Hirsch, and Foster (2006) for further details.

Recall from Section 3 that prevalence rates are defined as the proportions of the population who exhibit characteristics of interest. Let $\hat{p}_d$ represent the estimated prevalence rate of interest for domain *d*, with $\hat{p}_d$ defined as

$$\hat{p}_d = \frac{\hat{Y}_d}{\hat{N}_d},$$

where $\hat{Y}_d$ = estimated number of persons exhibiting the characteristic of interest in domain *d*, and $\hat{N}_d$ = estimated population total for domain *d*.

The variable defining the characteristic of interest (e.g., illicit drug use) is referred to as the *analysis* variable, and the variable defining the domain of interest (e.g., receipt of past year mental health treatment/counseling) is referred to as the *domain* variable. Suppose that the analysis variable has all its missing values imputed, but the domain variable does not employ the imputation of missing values. In such cases, the estimates $\hat{N}_d$ and $\hat{Y}_d$ may be negatively biased, and the $\hat{p}_d$ estimates also may be biased. To see this, suppose that the domain variable has *D* levels, and define

$$\hat{N} = \sum_{d=1}^{D} \hat{N}_d + \hat{N}_m,$$

where $\hat{N}$ = estimated population total, $\hat{N}_d$ = estimated population total for domain *d*, $d = 1, 2, ..., D$, and $\hat{N}_m$ = estimated population total corresponding to the missing values of the

[11] See http://www.samhsa.gov/data/NSDUH.aspx.

domain variable. Thus, if $\hat{N}_m$ is positive (i.e., there exist missing domain-variable responses), then at least one of the $\hat{N}_d$ estimates will be negatively biased. The presence of negative bias in at least one of the $\hat{Y}_d$ estimates can be similarly demonstrated if $\hat{Y}_m$ is positive, where $\hat{Y}_m$ = the estimated number of persons exhibiting the characteristic of interest and corresponding to the missing values of the domain variable. If either of $\hat{N}_m$ and $\hat{Y}_m$ is positive, then $\hat{p}_d$ may be biased by some unknown amount.

In the 2010 detailed tables (CBHSQ, 2011b) and the 2010 mental health detailed tables (CBHSQ, 2012a), potential bias in the $\hat{N}_d$, $\hat{Y}_d$, or $\hat{p}_d$ estimates was not treated, although footnotes included on the tables provide detailed information about which estimates were based on or excluded missing values. This problem may be illustrated by the following example, which corresponds to information presented in Tables 2.9A and 2.9B of the 2010 mental health detailed tables (CBHSQ, 2012a).

Mental health Table 2.9A presents estimates of the past year use of several types of illicit drugs among persons aged 12 to 17 for 2009 and 2010. These analysis variables are grouped into a two-level domain variable that is categorized according to whether a respondent had a past year major depressive episode (MDE). In 2010, mental health Table 3.2A shows the population estimate of persons aged 12 to 17 as approximately 24,347,000. However, the subdomain population estimates summed to approximately 23,816,000, resulting in an estimate of $\hat{N}_m$ = 530,000 (approximately 2.2 percent of the total population). This number represents the estimated population not assigned to either domain. This negative bias can extend to various analysis variables, such as "Illicit Drugs." In 2010, the population estimate of persons aged 12 to 17 who used illicit drugs in the past year was approximately 4,730,000. However, the subdomain population estimates summed to 4,600,000, resulting in an estimate of $\hat{Y}_m$ = 130,000 (approximately 2.8 percent of the total population).

Mental health Table 2.9B presents prevalence estimates of the past year use of several types of illicit drugs among persons aged 12 to 17 for 2009 and 2010. Because $\hat{N}_m$ is positive and $\hat{Y}_m$ is positive for the analysis variable, "Illicit Drugs," the prevalence estimates for this variable may be biased by some unknown amount across the two domains. The 2010 prevalence estimates reported in mental health Table 2.9B for youths who had or did not have past year MDE are 37.2 and 17.8 percent, respectively. It can be shown that the approximate range of possible bias values for each of these estimates is as follows: between -6.47 and 4.02 percent and between 0.49 and -0.32 percent, respectively.

4.2 Variance Estimation in the Presence of Missingness

SUDAAN uses the number of strata and the number of primary sampling units (PSUs) in its variance calculations, even if there are some PSUs where a variable is entirely missing for all sample members associated with that PSU (RTI International, 2008). The rationale behind this approach is that there may be individuals in the target population who have nonmissing values in PSUs where no sample members have nonmissing values.

To illustrate how this is operationalized in SUDAAN, consider the following example. Suppose there is interest in calculating the mean of some variable (say, X), but there are missing values associated with X. SUDAAN then creates an internal subpopulation indicator variable (say, δ), where $\delta = 1$ if X is not missing, and $\delta = 0$ if X is missing. Then SUDAAN internally calculates the mean and variance of X by using δX.

For the variance estimator based on the Taylor series linearization approach, one of the terms in the variance estimator consists of the sum of squared deviations of PSU-level totals about their stratum-level means, divided by the number of PSUs in the strata minus 1. Therefore, if SUDAAN encounters an incorrect number of PSUs within a stratum, then this term is incorrectly calculated. In addition, if there is only one PSU in a stratum, then the denominator for the variance term associated with that stratum becomes zero, and this causes the overall variance estimate to return an error message in SUDAAN. Hence, PSUs (associated with missing values) should never be excluded from an input file.

5. Sampling Error

As were the prevalence rates, all of the variance estimates for prevalences (including those for prevalence based on annual averages from combined data) were calculated using a method in SUDAAN[12] that is unbiased for linear statistics. This method is based on multistage clustered sample designs where the first-stage (primary) sampling units are drawn with replacement.

Due to the complex nature of the sampling design for the National Survey on Drug Use and Health (NSDUH) (specifically the use of stratified-clustering sampling), key nesting variables were created for use in SUDAAN to capture explicit stratification and to identify clustering. Starting with the 2005 NSDUH, there was a change made in the way the key nesting variables were defined. Each State sampling region (SSR) appears in a different variance estimation stratum every quarter. This method had the effect of assigning the regions to strata in a pseudo-random fashion while ensuring that each stratum consists of four SSRs from four different States.

Two replicates per year were defined within each variance stratum (VEREP). Each variance replicate consists of four segments, one for each quarter of data collection. One replicate consists of those segments that are "phasing out" or will not be used in the next survey year. The other replicate consists of those segments that are "phasing in" or will be fielded again the following year, thus constituting the 50 percent overlap between survey years. A segment stays in the same VEREP for the 2 years it is in the sample. This simplifies computing standard errors (SEs) for estimates based on combined data from adjacent survey years.

Although the SEs of estimates of means and proportions can be calculated appropriately in SUDAAN using a Taylor series linearization approach, SEs of estimates of totals may be underestimated in situations where the domain size is poststratified to data from the U.S. Census Bureau. Because of this underestimation, alternatives for estimating SEs of totals were implemented in all of the 2010 detailed tables (CBHSQ, 2011b) and the 2010 mental health detailed tables (CBHSQ, 2012a),[13] where appropriate.

Estimates of means or proportions, $\hat{p}_d$, such as drug use prevalence rates for a domain *d*, can be expressed as a ratio estimate:

$$\hat{p}_d = \frac{\hat{Y}_d}{\hat{N}_d},$$

where $\hat{Y}_d$ is a linear statistic estimating the number of substance users in the domain *d* and $\hat{N}_d$ is a linear statistic estimating the total number of persons in domain *d* (both users and nonusers).

[12] SUrvey DAta ANalysis (SUDAAN®) Software for Statistical Analysis of Correlated Data (RTI International, 2008).

[13] See http://www.samhsa.gov/data/NSDUH.aspx.

The SUDAAN software package is used to calculate direct estimates of $\hat{Y}_d$ and $\hat{N}_d$ and also can be used to estimate their respective SEs. A Taylor series approximation method implemented in SUDAAN provides estimates for $\hat{p}_d$ and its SE.

When the domain size, $\hat{N}_d$, is free of sampling error, an appropriate estimate of the SE for the total number of substance users is

$$\mathrm{SE}(\hat{Y}_d) = \hat{N}_d \mathrm{SE}(\hat{p}_d).$$

This approach is theoretically correct when the domain size estimates, $\hat{N}_d$, are among those forced to match their respective U.S. Census Bureau population estimates through the weight calibration process.[14] In these cases, $\hat{N}_d$ is not subject to a sampling error induced by the NSDUH design.

For estimated domain totals, $\hat{Y}_d$, where $\hat{N}_d$ is not fixed (i.e., where domain size estimates are not forced to match the U.S. Census Bureau population estimates), this formulation still may provide a good approximation if it can be assumed that the sampling variation in $\hat{N}_d$ is negligible relative to the sampling variation in $\hat{p}_d$. This is a reasonable assumption for most cases in this study.

For various subsets of estimates, the above approach yielded an underestimate of the variance of a total because $\hat{N}_d$ was subject to considerable variation. In 2000, an approach was implemented to reflect more accurately the effects of the weighting process on the variance of total estimates. This approach consisted of calculating SEs of totals for all estimates in a particular detailed table using the formula above when a majority of estimates in a table were among domains in which $\hat{N}_d$ was fixed during weighting or if it could be assumed that the sampling variation in $\hat{N}_d$ was negligible. Detailed tables in which the majority of estimates were among domains where $\hat{N}_d$ was subject to considerable variability were calculated directly in SUDAAN.

To improve on the accuracy of the SEs, a "mixed" method approach was implemented. This method was applied to selected tables in the 2004 NSDUH, and it was implemented across all tables starting with the 2005 NSDUH and continuing in the 2010 NSDUH. This approach assigns the method of SE calculation to domains within tables so that all estimates among a select set of domains with fixed $\hat{N}_d$ were calculated using the formula above, and all other estimates were calculated directly in SUDAAN, regardless of other estimates within the same table. The set of domains considered controlled (i.e., those with a fixed $\hat{N}_d$) was restricted to main effects and two-way interactions in order to maintain continuity between years. Domains consisting of three-way interactions may be controlled in 1 year but not necessarily in preceding

[14] For more information on the sampling weight calibration in the 2010 NSDUH, see the Person-Level Sampling Weight Calibration report in the *2010 National Survey on Drug Use and Health: Methodological Resource Book* (Chen et al., 2012).

or subsequent years. The use of such SEs did not affect the SE estimates for the corresponding proportions presented in the same sets of tables because all SEs for means and proportions are calculated directly in SUDAAN. Appendix A contains example SAS and SUDAAN code that demonstrates how to compute SEs of proportions as well as both types of SEs of totals (controlled or uncontrolled).

Table 1 contains a list of domains with a fixed $\hat{N}_d$ for the restricted use data file.[15] This table includes both the main effects and two-way interactions and may be used to identify the method of SE calculation employed for estimates of totals in the 2010 detailed tables (CBHSQ, 2011b) and the 2010 mental health detailed tables (CBHSQ, 2012a). For example, Table 1.23 of the 2010 detailed tables presents estimates of illicit drug use among persons aged 18 or older within the domains of gender, Hispanic or Latino (referred to as "Hispanic" hereafter) origin and race, education, and current employment. Estimates among the total population (age main effect), males and females (age by gender interaction), and Hispanics and non-Hispanics (age by Hispanic origin interaction) were treated as controlled in this table, and the formula above was used to calculate the SEs. The SEs for all other estimates, including white and black or African American (age by Hispanic origin by race interaction), were calculated directly from SUDAAN. It is important to note that estimates presented in the 2010 detailed tables and 2010 mental health detailed tables for racial groups are among non-Hispanics, unless noted otherwise. For instance, the domain for whites is actually non-Hispanic whites and is therefore a two-way interaction. Although not reported on in the 2010 detailed tables or 2010 mental health detailed tables, additional geographic interactions are also treated as domains with fixed $\hat{N}_d$ for other NSDUH analyses. Similar to geographic region and division, a State is considered a controlled domain, and two-way interactions with State and gender, Hispanic origin, quarter, and age group (12-17, 18-25, and 26 or older) are all treated as domains with fixed $\hat{N}_d$.

[15] See the estimation of totals section in the public use file introduction for a list of domains with fixed $\hat{N}_d$ for the 2010 public use file (CBHSQ, 2011a).

Table 1. Demographic and Geographic Domains Forced to Match Their Respective U.S. Census Bureau Population Estimates through the Weight Calibration Process, 2010

Main Effects	Two-Way Interactions
Age Group	
12-17	
18-25	**Age Group × Gender**
26-34	(e.g., Males Aged 12 to 17)
35-49	
50-64	
65 or Older	**Age Group × Hispanic Origin**
All Combinations of Groups Listed Above[1]	(e.g., Hispanics or Latinos Aged 18 to 25)
Gender	
Male	
Female	**Age Group × Race**
Hispanic Origin	(e.g., Whites Aged 26 or Older)
Hispanic or Latino	
Not Hispanic or Latino	
Race	**Age Group × Geographic Region**
White	(e.g., Persons Aged 12 to 25 in the Northeast)
Black or African American	
Geographic Region	
Northeast	**Age Group × Geographic Division**
Midwest	(e.g., Persons Aged 65 or Older in New England)
South	
West	
Geographic Division	**Gender × Hispanic Origin**
New England	(e.g., Not Hispanic or Latino Males)
Middle Atlantic	
East North Central	
West North Central	**Hispanic Origin × Race**
South Atlantic	(e.g., Not Hispanic or Latino Whites)
East South Central	
West South Central	
Mountain	
Pacific	

[1] Combinations of the age groups (including but not limited to 12 or older, 18 or older, 26 or older, 35 or older, and 50 or older) also were forced to match their respective U.S. Census Bureau population estimates through the weight calibration process.

Source: SAMHSA, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health, 2010.

6. Degrees of Freedom

To determine whether the observed difference between estimates is statistically significant, the degrees of freedom (*df*) are needed to locate the corresponding probability level (*p* value) of the test statistic. The test statistic is computed from the sample data and represents a numerical summary of the difference between the estimates under consideration; it is a random variable that has a predetermined distribution (such as Student's *t*, chi-square, or *F*). The degrees of freedom characterize the amount of variation expected in the estimation of sampling error and are used in conjunction with the test statistic to determine probabilities and evaluate statistical significance. In statistics, the number of degrees of freedom refers to the number of independent units of information in a sample relevant to the estimation of a parameter or calculation of a statistic. In general, the degrees of freedom of a parameter estimate is equal to the number of independent observations that go into the estimate minus the number of other parameters that need to be estimated as an intermediate step. The degrees of freedom are also used to compute the confidence intervals (CIs) discussed in Section 8. The upper and lower limits of the CIs are defined by a constant value that is chosen to yield a level of confidence based on the degrees of freedom.

Starting in 2005, there was a change in definition to the variance estimation strata for the National Survey on Drug Use and Health (NSDUH). This change in definition, which was applied to the 2005 through 2010 NSDUHs, has the effect of increasing the number of degrees of freedom for State-level estimates while preserving the number of degrees of freedom for national estimates (900). The degrees of freedom are calculated as the number of primary sampling units (variance replicates) minus the number of strata for the data being analyzed. Because the NSDUH sample design provides for estimates by State in all 50 States plus the District of Columbia, States may be viewed as the first level of stratification. When producing NSDUH estimates on the national level, including estimates based on annual averages from combined data, there are 900 degrees of freedom. If an analysis only involves certain States, the degrees of freedom change depending on whether the State is a large sample or small sample State. The large sample States (i.e., California, Florida, Illinois, Michigan, New York, Ohio, Pennsylvania, and Texas) have 192 degrees of freedom because each large State is in 192 strata. All of the other States (i.e., the small sample States, which include the District of Columbia) have 48 degrees of freedom because each small State is in 48 different strata. Note that the 2010 detailed tables (CBHSQ, 2011b) and the 2010 mental health detailed tables (CBHSQ, 2012a)[16] use 900 degrees of freedom for all estimates, including those for geographic regions and divisions. Appendix A contains an example demonstrating how to define the degrees of freedom within the SUDAAN (RTI International, 2008) procedure to compute design-based estimates.

For an analysis of a group of States, the degrees of freedom would be less than or equal to the sum of the degrees of freedom for each individual State due to overlap of strata. The specific number of degrees of freedom can be computed by counting the unique values of VESTR (variance estimation [pseudo] stratum) for the particular geographic area of interest. For these type of specific State analyses (or other subpopulations of interest), the degrees of

[16] See http://www.samhsa.gov/data/NSDUH.aspx.

freedom can be specifically indicated in SUDAAN (RTI International, 2008); otherwise, the degrees of freedom are computed using the entire dataset. Similar methods can be used to compute appropriate degrees of freedom for any geographic region comprised of counties or States as well. The technique of counting the number of unique values of VESTR can also be used for analyses combining survey data across years.

7. Statistical Significance of Differences

Once the degrees of freedom have been determined, various methods used to compare prevalence estimates may be employed. This section describes some of these methods. Customarily, the observed difference between estimates is evaluated in terms of its statistical significance. Statistical significance is based on the *p* value of the test statistic and refers to the probability that a difference as large as that observed would occur due to random variability in the estimates if there were no difference in the prevalence rates being compared. The significance of observed differences is generally reported at the .05 and .01 levels when the *p* value is defined as less than or equal to the designated significance level.

Significance tests were conducted on differences between prevalence estimates from the 2010 National Survey on Drug Use and Health (NSDUH) and previous years of NSDUH back to 2002. Due to survey design changes implemented in 2002, data from the 2002 through 2010 NSDUHs should not be compared with data from earlier survey years. Significance tests also were conducted on differences of prevalence estimates between combined 2007-2008 survey data and combined 2009-2010 survey data. Within-year tests were conducted on differences between prevalence estimates for various populations (or subgroups) of interest using data from the 2010 survey.

When comparing prevalence estimates, one can test the null hypothesis (no difference between rates) against the alternative hypothesis (there is a difference in prevalence rates) using the standard *t* test (with the appropriate degrees of freedom) for the difference in proportions test, expressed as

$$t_{df} = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\text{var}(\hat{p}_1) + \text{var}(\hat{p}_2) - 2\,\text{cov}(\hat{p}_1, \hat{p}_2)}},$$

where *df* = the appropriate degrees of freedom, $\hat{p}_1$ = first prevalence estimate, $\hat{p}_2$ = second prevalence estimate, $\text{var}(\hat{p}_1)$ = variance of first prevalence estimate, $\text{var}(\hat{p}_2)$ = variance of second prevalence estimate, and $\text{cov}(\hat{p}_1, \hat{p}_2)$ = covariance between $\hat{p}_1$ and $\hat{p}_2$. Note that the first and second prevalence estimates may take the form of prevalence estimates from two different survey years (e.g., 2009 and 2010, respectively), prevalence estimates from sets of combined survey data (e.g., 2007-2008 annual averages and 2009-2010 annual averages, respectively), or prevalence estimates for populations of interest within a single survey year.

Under the null hypothesis, the test statistic *t* is a random variable that asymptotically follows a *t*-distribution. Therefore, calculated values of *t*, along with the appropriate degrees of freedom, can be used to determine the corresponding probability level (i.e., *p* value). Whether testing for differences between years or from different populations within the same year, the covariance term in the formula for *t* will, in general, not be equal to zero. SUDAAN is used to compute estimates of *t* along with the associated *p* values such that the covariance term is calculated by taking the sample design into account (RTI International, 2008). A similar procedure and formula for *t* are used for estimated totals; however, it should be noted that

because it was necessary to calculate the standard error (SE) outside SUDAAN for domains forced by the weighting process to match their respective U.S. Census Bureau population estimates, the corresponding test statistics also were computed outside SUDAAN. SAS and SUDAAN examples showing the computational methods for generating *p* values of estimates of *t* and estimated totals can be found in Appendix A.

Under the null hypothesis, the test statistic with known variances asymptotically follows a standard normal (*Z*) distribution. However, because the variances of the test statistic are estimated, its distribution is more accurately described by the *t*-distribution for finite sample sizes. A sufficiently large sample size is required for the asymptotic properties to take effect, and this is usually determined through the suppression criteria applied to the estimates (see Section 10). As the degrees of freedom approach infinity, the *t*-distribution approaches the *Z* distribution. That is, because most of the statistical tests performed have 900 degrees of freedom, the *t* tests performed produce approximately the same numerical results as if a *Z* test had been performed.

When comparing population subgroups defined by three or more levels of a categorical variable, log-linear chi-square tests of independence of the subgroup and the prevalence variables were conducted first to control the error level for multiple comparisons. If Shah's Wald *F* test (transformed from the standard Wald chi-square) indicated overall significant differences, the significance of each particular pairwise comparison of interest was tested using SUDAAN analytic procedures to properly account for the sample design (RTI International, 2008).

If SUDAAN is not available to compute the significance testing, using published estimates can provide similar testing results. When comparing prevalence rates shown with SEs, independent *t* tests for the difference of proportions can be performed and usually will provide the same results as tests performed in SUDAAN. However, where the *p* value is close to the predetermined level of significance, results may differ for two reasons: (1) the covariance term is included in the SUDAAN tests, whereas it is not included in independent *t* tests; and (2) the reduced number of significant digits shown in the published estimates may cause rounding errors in the independent *t* tests. Although not generated in all NSDUH publications, some publications do include sampling error in the form of 95 percent confidence intervals (CIs). In terms of testing for differences between prevalence rates shown with 95 percent CIs, it is important to note that two overlapping 95 percent CIs do not imply that their rates are statistically equivalent at the 5 percent level of significance. For additional information, see Schenker and Gentleman (2001) and Payton, Greenstone, and Schenker (2003).

8. Confidence Intervals

In some National Survey on Drug Use and Health (NSDUH) publications, sampling error has been quantified using 95 percent confidence intervals (CIs). Frequently, NSDUH estimates are small percentages (i.e., are close to 0), and in that case, a logit transformation of the estimate provides favorable properties. For example, the logit transformation yields asymmetric interval boundaries between 0 and 1 that are more balanced with respect to the true probability that the true value falls below or above the interval boundaries. This is in part due to the fact that for values close to 0, the distribution of a logit transformed estimate approximates the normal distribution more closely than the standard estimate. Standard symmetric CIs for small proportions may also lead to the undesirable result of a lower CI limit that is less than 0.

To illustrate the method, let the proportion P_d represent the true prevalence rate for a particular analysis domain *d*. Then the logit transformation of P_d , commonly referred to as the "log odds," is defined as

$$L = \ln[P_d / (1 - P_d)],$$

where "1n" denotes the natural logarithm.

Letting $\hat{p}_d$ be the estimate of the domain proportion, the log odds estimate becomes

$$\hat{L} = \ln[\hat{p}_d /(1 - \hat{p}_d)].$$

The lower and upper confidence limits of *L* are formed as

$$A = \hat{L} - K\left[\frac{\sqrt{\text{var}(\hat{p}_d)}}{\hat{p}_d(1-\hat{p}_d)}\right],$$
$$B = \hat{L} + K\left[\frac{\sqrt{\text{var}(\hat{p}_d)}}{\hat{p}_d(1-\hat{p}_d)}\right],$$

where $\text{var}(\hat{p}_d)$ is the variance estimate of $\hat{p}_d$, the quantity in brackets is a first-order Taylor series approximation of the standard error (SE) of $\hat{L}$, and *K* is the critical value of the *t*-distribution associated with a specified level of confidence and degrees of freedom (*df*). For example, to produce 95 percent confidence limits for national estimates, the value of *K* would be 1.96 based on 900 degrees of freedom (similarly, for large States, *K* would be 1.97 based on 192 degrees of freedom, and for small States, *K* would be 1.98 based on 48 degrees of freedom).

Although the distribution of the logit transformed estimate, $\hat{L}$, is asymptotically normal, the variance term in the CI is estimated, and a critical value from the *t*-distribution is therefore appropriate when calculating CIs. A sufficiently large sample size is required for the asymptotic

properties to take effect, and this is usually determined through the suppression criteria applied to the estimates (see Section 10).

Applying the inverse logit transformation to *A* and *B* above yields a CI for $\hat{p}_d$ as follows:

$$\hat{p}_{d,lower} = \frac{1}{1+\exp(-A)},$$

$$\hat{p}_{d,upper} = \frac{1}{1+\exp(-B)},$$

where "exp" denotes the inverse log transformation. The lower and upper CI endpoints for percentage estimates are obtained by multiplying the lower and upper endpoints of $\hat{p}_d$ by 100.

The CI for the estimated domain total, $\hat{Y}_d$, as estimated by

$$\hat{Y}_d = \hat{N}_d \cdot \hat{p}_d,$$

is obtained by multiplying the lower and upper limits of the proportion CI by $\hat{N}_d$. For domain totals $\hat{Y}_d$, where $\hat{N}_d$ is not fixed, the CI approximation assumes that the sampling variation in $\hat{N}_d$ is negligible relative to the sampling variation in $\hat{p}_d$.

9. Incidence Estimates

In epidemiological studies, incidence is defined as the number of new cases of a disease occurring within a specific period of time. Similarly, in substance use studies, incidence refers to the first use of a particular substance.

Starting with the 2004 National Survey on Drug Use and Health (NSDUH) data, the evaluation of trends in the initiation of drug use was presented by estimates of past year drug use incidence or initiation (i.e., the number of users whose first use was within the 12 months prior to their interview date). This incidence measure, termed "past year initiation," is determined by self-reported past year use, age at first use, year and month of most recent new use, and the interview date.

Since 1999, the NSDUH questionnaire allowed for the collection of year and month of first use for recent initiates (i.e., persons who used a particular substance for the first time in a given survey year). Month, day, and year of birth also were obtained directly or imputed for item nonrespondents as part of the data processing. In addition, the questionnaire call record provided the date of the interview. By imputing a day of first use within the year and month of first use, a specific date of first use, $t_{fu,d,i}$, can be used for estimation purposes.

Past year initiation among persons using a substance in the past year can be viewed as an indicator variable defined as follows:

$$I_{(Past\ Year\ Initiate)}(i) = \begin{cases} 1 & \text{if } \left(DOI_i MOI_i YOI_i - t_{fu,d,i}\right) \le 365 \\ 0 & \text{otherwise} \end{cases},$$

where DOI_i, MOI_i, and YOI_i denote the day, month, and year of the interview for person *i*, respectively, and $t_{fu,d,i}$ denotes the date of first use associated to person *i*.

The calculation of past year initiation does not take into account whether the respondent initiated substance use while a resident of the United States. This method of calculation has little effect on past year estimates and provides direct comparability with other standard measures of substance use because the populations of interest for the measures will be the same (i.e., both measures examine all possible respondents and do not restrict to those only initiating substance use in the United States).

One important note for incidence estimates is the relationship between a main substance category and subcategories of substances (e.g., illicit drugs would be a main category and inhalants and marijuana would be examples of subcategories in relation to illicit drugs). For most measures of substance use, any member of a subcategory is by necessity a member of the main category (e.g., if a respondent is a past month user of a particular drug, then he or she is also a past month user of illicit drugs in general). However, this is not the case with regard to incidence statistics. Because an individual can only be an initiate of a particular substance category (main or sub) a single time, a respondent with lifetime use of multiple substances may not,

by necessity, be included as an initiate of a main category, even if he or she were an initiate for a particular subcategory because his or her first initiation of other substances could have occurred earlier.

In addition to estimates of the number of persons initiating use of a substance in the past year, estimates of the mean age of past year first-time users of these substances were computed. Unless specified otherwise, estimates of the mean age at initiation in the past 12 months have been restricted to persons aged 12 to 49 so that the mean age estimates reported are not influenced by those few respondents who were past year initiates at age 50 or older. As a measure of central tendency, means are influenced heavily by the presence of extreme values in the data, and this constraint should increase the utility of these results to health researchers and analysts by providing a better picture of the substance use initiation behaviors among the civilian, noninstitutionalized population in the United States. This constraint was applied only to estimates of mean age at first use and does not affect estimates of incidence.

Because NSDUH is a survey of persons aged 12 years old or older at the time of the interview, younger individuals in the sample dwelling units are not eligible for selection into the NSDUH sample. Some of these younger persons may have initiated substance use during the past year. As a result, past year initiate estimates suffer from undercoverage when one can think of the estimates as reflecting all initial users regardless of current age. For earlier years, data can be obtained retrospectively based on the age at and date of first use. As an example, persons who were 12 years old on the date of their interview in the 2010 survey may have reported initiating use of cigarettes between 1 and 2 years ago; these persons would have been past year initiates reported in the 2009 survey had persons who were 11 years old on the date of the 2009 interview been allowed to participate in the survey. Similarly, estimates of past year use by younger persons (aged 10 or younger) can be derived from the current survey, but they apply to initiation in prior years—not the survey year.

To get an impression of the potential undercoverage in the current year, reports of substance use initiation reported in 2010 by persons aged 12 or older were estimated for the years in which these persons would have been 1 to 11 years younger. These estimates do not necessarily reflect behavior by persons who were 1 to 11 years younger in 2010. Instead, the data for the 11-year-olds reflect initiation in the year prior to the 2010 survey, the data for the 10-year-olds reflect behavior between the 12th and 23rd month prior to the 2010 survey, and so on. A very rough way to adjust for the difference in the years that the estimate pertains to without considering changes to the population is to apply an adjustment factor to each age-based estimate of past year initiates. The adjustment factor can be based on a ratio of lifetime users aged 12 to 17 in 2010 to the same estimates for the prior applicable survey year. To illustrate the calculation, consider past year use of alcohol. In the 2010 survey, 77,477 persons who were 12 years old in 2009 were estimated to have initiated use of alcohol between 1 and 2 years earlier. These persons would have been past year initiates in the 2009 survey conducted on the same dates had the 2009 survey covered younger persons. The estimated number of lifetime users currently aged 12 to 17 was 8,573,937 for 2010 and 9,382,813 for 2009, indicating fewer overall initiates of alcohol use among persons aged 17 or younger in 2010. Thus, an adjusted estimate of initiation of alcohol use by persons who were 11 years old in 2010 is given by

$$(Estimated\ Past\ Year\ Initiates\ Age\ 11)_{2009} * \frac{(Estimated\ Lifetime\ Users\ Age\ 12\ to\ 17)_{2010}}{(Estimated\ Lifetime\ Users\ Age\ 12\ to\ 17)_{2009}}$$

Numerically, this yielded an adjusted estimate of 70,798 persons who were 11 years old on a 2010 survey date and initiated use of alcohol in the past year:

$$77,477 * \frac{8,573,937}{9,382,813} = 70,798.$$

A similar procedure was used to adjust the estimated number of past year initiates among persons who would have been 10 years old on the date of the interview in 2008 and for younger persons in earlier years. The overall adjusted estimate for past year initiates of alcohol use by persons aged 11 or younger on the date of the interview was 167,528, or about 3.6 percent of the estimate based on past year initiation by persons aged 12 or older only (167,528 ÷ 4,673,215 = 0.0358).

Based on similar analyses, the estimated undercoverage of past year initiates aged 11 or younger was about 4.1 percent for cigarettes, about 0.7 percent for marijuana, and about 19.4 percent for inhalants. These 2010 results are comparable with undercoverage estimates presented in prior reports using data from the 2005 through 2009 surveys.

The undercoverage of past year initiates aged 11 or younger also affects the mean age at first use estimate. An adjusted estimate of the mean age at first use was calculated using a weighted estimate of the mean age at first use based on the current survey and the numbers of persons aged 11 or younger in the past year obtained in the aforementioned analysis for estimating undercoverage of past year initiates. Analysis results showed that the mean age at first use was changed from 17.2 to 16.9 for alcohol, from 17.3 to 16.9 for cigarettes, from 18.4 to 18.3 for marijuana, and from 16.3 to 15.0 for inhalants. The decreases reported above are comparable with results generated in prior survey years.

10. Suppression of Estimates with Low Precision

Direct survey estimates that were considered to be unreliable due to unacceptably large sampling errors were not reported, but rather were noted by an asterisk (*). The criteria used to assess the need to suppress direct survey estimates were based on prevalence (for proportion estimates), the relative standard error (RSE) (defined as the ratio of the standard error [SE] over the estimate), nominal (actual) sample size, and effective sample size for each estimate.

Proportion estimates $(\hat{p})$, or rates, within the range $0 < \hat{p} < 1,$ and corresponding estimated numbers of users were suppressed if

$$\mathrm{RSE}[-\ln(\hat{p})] > .175 \text{ when } \hat{p} \le .5$$

or

$$\mathrm{RSE}[-\ln(1-\hat{p})] > .175 \text{ when } \hat{p} > .5\,.$$

Based on a first-order Taylor series approximation of RSE $[-\ln(\hat{p})]$ and RSE $[-\ln(1-\hat{p})]$, the following equation was derived and used for computational purposes when applying a suppression rule dependent on effective sample sizes:

$$\frac{\mathrm{SE}(\hat{p})/\hat{p}}{-\ln(\hat{p})} > .175 \text{ when } \hat{p} \le .5,$$

or

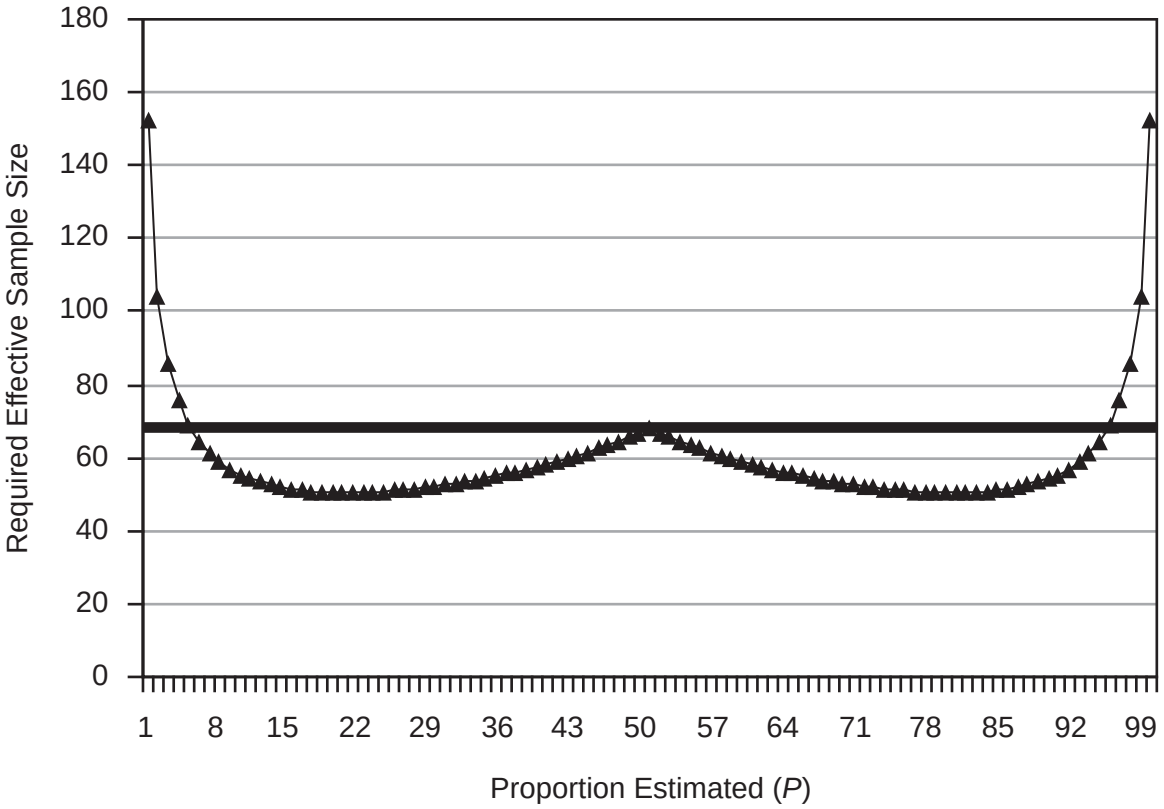
$$\frac{\mathrm{SE}(\hat{p})/(1-\hat{p})}{-\ln(1-\hat{p})} > .175 \text{ when } \hat{p} > .5\,.$$

The separate formulas for $\hat{p} \le .5$ and $\hat{p} > .5$ produce a symmetric suppression rule; that is, if $\hat{p}$ is suppressed, $1-\hat{p}$ will be suppressed as well. See Figure 1 for a graphical representation of the required minimum effective sample sizes as a function of the proportion estimated. When $.05 < \hat{p} < .95,$ the symmetric properties of the rule produce local minimum effective sample sizes at $\hat{p} = .2$ and again at $\hat{p} = .8$, such that an effective sample size of greater than 50 is required; this means that estimates would be suppressed for these values of $\hat{p}$ unless the effective sample sizes were greater than 50. Within this same interval of $.05 < \hat{p} < .95,$ a local maximum effective sample size of 68 is required at $\hat{p} = .5$. So, to simplify requirements and maintain a conservative suppression rule, estimates of $\hat{p}$ between .05 and .95, which had effective sample sizes below 68, were suppressed.

The effective sample size for a domain is a function of the nominal sample size and the design effect (i.e., nominal sample size/design effect). During the original development of this suppression rule, the design effect was calculated outside SUDAAN (RTI International, 2008) in SAS. Since the 2005 National Survey on Drug Use and Health (NSDUH) analysis, the direct SUDAAN design effect was used to provide a more precise and accurate reflection of the design

effect (due to the removal of several possible rounding errors) when compared with the SAS method used in the past. The differences between the direct SUDAAN design effects and the SAS-calculated design effects only occur at approximately the tenth decimal place or later; however, previously published estimates that were on the borderline of being suppressed or unsuppressed due to the effective sample size suppression rule may potentially change from suppressed to unsuppressed, or vice versa.

Figure 1. Required Effective Sample in the 2010 NSDUH as a Function of the Proportion Estimated



In addition, a minimum nominal sample size suppression criterion (n = 100) that protects against unreliable estimates caused by small design effects and small nominal sample sizes was employed. Table 2 shows a formula for calculating design effects. Prevalence estimates also were suppressed if they were close to 0 or 100 percent (i.e., if $\hat{p} < .00005$ or if $\hat{p} \geq .99995$).

Beginning with the 1991 survey, the suppression rule for proportions based on RSE $[-\ln(\hat{p})]$ described above replaced an older rule in which data were suppressed whenever RSE ($\hat{p}$) > .5. This rule was changed because the older rule imposed a very stringent application for small $\hat{p}$, but a very lax application for large $\hat{p}$. The new rule ensured a more uniformly stringent application across the whole range of $\hat{p}$ (i.e., from 0 to 1). The old rule also was asymmetric in the sense that suppression only occurred in terms of $\hat{p}$; that is, there was no complementary rule for (1 – $\hat{p}$), which the new suppression rules now account for.

Estimates of totals were suppressed if the corresponding prevalence rates were suppressed. Estimates of means not bounded between 0 and 1 (e.g., mean age at first use) were suppressed if the RSEs of the estimates were larger than .5 or if the sample sizes were smaller than 10 respondents.

The suppression criteria for various NSDUH estimates are summarized in Table 2, and sample SAS code demonstrating how to implement these rules can be found in Appendix A.

Table 2. Summary of 2010 NSDUH Suppression Rules

Estimate	Suppress if:
Prevalence Rate, $\hat{p}$, with Nominal Sample Size, n, and Design Effect, $deff$ $\left(deff = \frac{n[\mathrm{SE}(\hat{p})]^2}{\hat{p}(1-\hat{p})} \right)$	(1) The estimated prevalence rate, $\hat{p}$, is < 0.00005 or ≥ 0.99995, or (2) $\frac{\mathrm{SE}(\hat{p}) \ / \ \hat{p}}{-\ln(\hat{p})} > 0.175$ when $\hat{p} \le 0.5$, or $\frac{\mathrm{SE}(\hat{p}) \ / \ (1 - \hat{p})}{-\ln(1 - \hat{p})} > 0.175$ when $\hat{p} > 0.5$, or (3) Effective $n < 68$, where Effective $n = \frac{n}{deff} = \frac{\hat{p}(1-\hat{p})}{\left[\mathrm{SE}(\hat{p})\right]^2}$, or (4) $n < 100$. Note: The rounding portion of this suppression rule for prevalence rates will produce some estimates that round at one decimal place to 0.0 or 100.0 percent but are not suppressed from the tables.
Estimated Number (Numerator of $\hat{p}$)	The estimated prevalence rate, $\hat{p}$, is suppressed. Note: In some instances when $\hat{p}$ is not suppressed, the estimated number may appear as a 0 in the tables. This means that the estimate is greater than 0 but less than 500 (estimated numbers are shown in thousands).
Mean Age at First Use, $\bar{x}$, with Nominal Sample Size, n	(1) $\mathrm{RSE}(\bar{x}) > 0.5$, or (2) $n < 10$.

deff = design effect; RSE = relative standard error; SE = standard error.

Source: SAMHSA, Center for Behavioral Health Statistics and Quality, National Survey on Drug Use and Health, 2010.

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Appendix A: Documentation for Conducting Various Statistical Procedures: SAS and SUDAAN Examples

This appendix contains example SAS® and SUDAAN® code that produces estimates of past month alcohol use by year (2009 and 2010) and gender (males and females) using the statistical procedures documented within this report and implemented in the 2010 detailed tables (Center for Behavioral Health Statistics and Quality [CBHSQ], 2011a) and the 2010 mental health detailed tables (CBHSQ, 2012a). The first SUDAAN[1] example (Exhibit A.1) produces estimates as described in Section 3 of the report, and the second (Exhibit A.4) and third (Exhibit A.6) SUDAAN examples perform statistical tests of differences for the generated estimates as described in Section 7 of the report. The first SAS example (Exhibit A.2) calculates the standard error (SE) of the total for controlled domains as discussed in Section 5, and the second SAS example (Exhibit A.3) implements the suppression rule as shown in Section 10. Note that the SE of the total for uncontrolled domains is calculated within SUDAAN. The third SAS example (Exhibit A.5) produces the *p* value for the test of differences between totals for uncontrolled domains, whereas the last three SAS examples (Exhibits A.7, A.8, and A.9) combined produce the *p* value for the test of differences between totals for controlled domains.

Before running the SUDAAN procedures, the input dataset must be sorted by the nesting variables (VESTR and VEREP), or the NOTSORTED option must be used for SUDAAN to create an internal copy of the input dataset properly sorted by the nesting variables. The SUDAAN procedure DESCRIPT can then be run to produce weighted and unweighted sample sizes, means, totals, SEs of means and totals, as well as *p* values for testing of the means and totals.

The following options are specified within the SUDAAN examples below to correctly produce estimates using the National Survey on Drug Use and Health (NSDUH) data.

DESIGN=WR (with replacement)

Due to the NSDUH sample design, estimates are calculated using a method in SUDAAN that is unbiased for linear statistics. This method is based on multistage clustered sample designs where the first-stage (primary) sampling units are drawn with replacement.

Nesting Variables (VESTR and VEREP)

The nesting variables are used to capture explicit stratification and to identify clustering with the NSDUH data, which are needed in order to compute the variance estimates correctly. Two replicates per year were defined within each variance stratum (VESTR). Each variance replicate (VEREP) consists of four segments, one for each quarter of data collection. One replicate consists of those segments that are "phasing out" or will not be used in the next survey year. The other replicate consists of those segments that are "phasing in" or will be fielded again the following year, thus constituting the 50 percent overlap between survey years. A segment stays in the same VEREP for the 2 years it is in the sample. This simplifies computing SEs for estimates based on combined data from adjacent survey years.

[1] SUrvey DAta ANalysis (SUDAAN®) Software for Statistical Analysis of Correlated Data (RTI International, 2008).

Degrees of Freedom (DDF)

As described in Section 6 of this report, the degrees of freedom (*df*) are 900 for national estimates, 192 for large States (California, Florida, Illinois, Michigan, New York, Pennsylvania, Ohio, Texas), and 48 for all other States. For an analysis of a group of States, the degrees of freedom can be less than or equal to the sum of the degrees of freedom for each individual State due to overlap of variance strata. The specific number of degrees of freedom can be computed by counting the unique values of VESTR for the particular geographic area of interest. The technique of counting the number of unique values of VESTR can also be used for analyses combining survey data across years. When combining any years of data from 2005 through 2010, the degrees of freedom remain the same as if it were a single year (e.g., 900 for national estimates) because these years are part of the same sample design. When comparing estimates in two domains with different degrees of freedom, err on the conservative side and use the smaller degrees of freedom.

Design Effect (DEFT4)

This option within SUDAAN provides the correct measure of variance inflation due to stratification (or blocking), clustering, and unequal weighting in NSDUH estimation.

The following SAS and SUDAAN examples apply the specific NSDUH options described previously to compute estimates, apply the suppression rule, and perform significance testing by using the data produced by the example in Exhibit A.1.

Generation of Estimates

Exhibit A.1 demonstrates how to compute various types of estimates for past month alcohol use by year and gender, including the prevalence estimate (MEAN), SE of the mean (SEMEAN), weighted sample size (WSUM), unweighted sample size (NSUM), weighted total (TOTAL), and the SE of the totals (SETOTAL). Whether or not the SETOTAL is taken directly from SUDAAN depends on whether or not the specified domain (i.e., gender in this example) is among those forced to match their respective U.S. Census Bureau population estimates through the weight calibration process. See the section below on SEs for additional information.

Exhibit A.1 SUDAAN DESCRIPT Procedure (Estimate Generation)

```
PROC SORT DATA=DATANAME; /*SAS code to sort output dataset by
Nesting Variables*/
BY VESTR VEREP;
RUN;

PROC DESCRIPT DATA=DATANAME DDF=900 DESIGN=WR FILETYPE=SAS DEFT4;
NEST VESTR VEREP;
WEIGHT ANALWT;   /*Standard single-year, person-level analysis
weight*/
VAR ALCMON;   /*Past month alcohol analysis variable*/
SUBGROUP YEAR IRSEX;
/*Year variable, where 2009=1 & 2010=2*/
```

Exhibit A.1 SUDAAN DESCRIPT Procedure (Estimate Generation) (continued)

```
      /*Gender variable, where male=1 & female=2*/
LEVELS 2 2;
TABLES YEAR*IRSEX; /*Gender by year*/

PRINT WSUM NSUM MEAN SEMEAN TOTAL SETOTAL / REPLACE STYLE=NCHS;
OUTPUT WSUM MEAN SEMEAN TOTAL SETOTAL NSUM DEFFMEAN /REPLACE
   NSUMFMT=F8.0 WSUMFMT=F12.0 MEANFMT=F15.10 SEMEANFMT=F15.10
   DEFFMEANFMT=F15.10 TOTALFMT=F12.0 SETOTALFMT=F12.0
   FILENAME="OUT.SUDFILE";
TITLE "ESTIMATES OF PAST MONTH ALCOHOL BY YEAR AND GENDER";
RUN;
```

Note: The following CLASS statement could be used in place of SUBGROUP and LEVELS statements in the above example:

```
CLASS YEAR IRSEX;
```

Standard Errors

As discussed in Section 5 of the report, the SE for the mean (or proportion) comes directly out of SUDAAN in the output variable SEMEAN (Exhibit A.1). However, to compute the SE of the totals, NSDUH implements different methods depending on whether the specified domain (i.e., gender in this example) is controlled or uncontrolled for during the weighting process. If a domain is uncontrolled for (i.e., it is not one of the domains described in Table 1 in Section 5), then the SE of the total comes directly out of SUDAAN in the output variable SETOTAL. If the domain is controlled for (i.e., it is one of the domains described in Table 1), then the SE of the total is calculated outside of SUDAAN as SETOTAL (SE of controlled domain) = WSUM (weighted sample size) * SEMEAN (SE for the mean/proportion). Because gender is controlled for, the SE of the totals would not be taken directly from the Exhibit A.1 example but rather would be computed using this formula as shown in Exhibit A.2.

Exhibit A.2 SAS Code (Calculation of Standard Error of Totals for Controlled Domains)

```
DATA ESTIMATE;
SET OUT.SUDFILE; /*input the output file from above SUDAAN
                   procedure*/

/*************************************************************
  Define SETOTAL for gender because it is a controlled domain.
   In the SUDAAN procedure above, IRSEX is in the subgroup
     Statement with 2 levels indicated. Therefore, values for
     0=total male & females, 1=males, and 2=females are
     automatically produced.

*************************************************************/

IF IRSEX IN (0,1,2) THEN SETOTAL=WSUM*SEMEAN;

RUN;
```

Suppression Rule

As described in Section 10 of the report, each published NSDUH estimate goes through a suppression rule to detect if the estimate is unreliable due to an unacceptably large sampling error. The suppression rules as they apply to different types of estimates are shown in Table 2 in Section 10. The example in Exhibit A.3 applies the prevalence rate rule. Note that there is a different suppression rule for averages.

Exhibit A.3 SAS Code (Implementation of Prevalence Rate Suppression Rule)

```
DATA ESTIMATE;
SET OUT.SUDFILE; /*input the output file from above SUDAAN
                   procedure*/

/******APPLY THE PREVALENCE RATE SUPRESSION RULE*******/

/* CALCULATE THE RELATIVE STANDARD ERROR */
      IF MEAN GT 0.0 THEN RSE=SEMEAN/MEAN;

/* CALCULATE THE RELATIVE STANDARD ERROR OF NATURAL LOG P */
            IF 0.0 LT MEAN LE 0.5 THEN RSELNP=RSE/ABS(LOG(MEAN));
      ELSE IF 0.5 LT MEAN LT 1.0 THEN
      RSELNP=RSE*(MEAN/(1-MEAN))/(ABS(LOG(1-MEAN)));

/*CALCULATE THE EFFECTIVE SAMPLE SIZE*/
      EFFNSUM=NSUM/DEFFMEAN;

IF (MEAN LT .00005) OR (MEAN GE 0.99995) OR (RSELNP GT 0.175) OR
(EFFNSUM < 68) OR (NSUM <100) THEN SUPRULE=1;

RUN;
```

Statistical Tests of Differences

As described in Section 7 of the report, significance tests were conducted on differences of prevalence estimates between the 2010 NSDUH and previous years of NSDUH back to 2002, as well as differences of prevalence estimates between combined 2007-2008 survey data and combined 2009-2010 survey data. Note that for year-to-year tests of differences, if the estimate for either year is suppressed, the resulting *p* value is also suppressed.

Testing of differences requires a separate PROC DESCRIPT run from the initial DESCRIPT run that produces the corresponding yearly estimates. Tests of differences can be generated using DESCRIPT's CONTRAST, PAIRWISE, or DIFFVAR statements. The SUDAAN example in Exhibit A.4 uses the DIFFVAR statement to test for differences between the 2009 and 2010 past month alcohol use estimates for all persons aged 12 or older (IRSEX=0), all males (IRSEX=1), and all females (IRSEX=2).

Similar to computing the SEs of the totals, calculating *p* values for tests of differences of totals differs depending on whether an estimate is considered to be from a controlled domain or an uncontrolled domain. Both ways are described below with accompanying example code.

Exhibits A.4 and A.5 show example code for uncontrolled domains, and Exhibits A.4, A.6, A.7, A.8, and A.9 show example code for controlled domains.

Exhibit A.4 SUDAAN DESCRIPT Procedure (Tests of Differences)

```
PROC DESCRIPT DATA=DATANAME DDF=900 DESIGN=WR FILETYPE=SAS;
NEST VESTR VEREP;
WEIGHT ANALWT;
VAR ALCMON;
SUBGROUP YEAR IRSEX;
LEVELS 2 2;
TABLES IRSEX;
DIFFVAR YEAR=(1 2); /*Tests of differences between 2009(year=1)
                      and 2010 (year=2)*/
PRINT WSUM NSUM MEAN SEMEAN TOTAL SETOTAL T_MEAN P_MEAN /
   REPLACE STYLE=NCHS;
OUTPUT WSUM MEAN SEMEAN TOTAL SETOTAL NSUM T_MEAN P_MEAN /
   REPLACE
   NSUMFMT=F8.0 WSUMFMT=F12.0 MEANFMT=F15.10 SEMEANFMT=F15.10
   TOTALFMT=F12.0 SETOTALFMT=F12.0 FILENAME="OUT.SUDTESTS";
TITLE "TESTS OF DIFFERENCES BETWEEN 2009 AND 2010 ESTIMATES OF
PAST MONTH ALCOHOL BY YEAR AND GENDER";
RUN;
```

```
Note: The following CLASS statement could be used in place of SUBGROUP
and LEVELS statements in the above example:
   CLASS YEAR IRSEX;
```

When one or more contrasts are specified in SUDAAN, as in the DIFFVAR statement above, the output variable MEAN becomes the contrast mean, and SEMEAN becomes the SE of the contrast mean. The example above also outputs the t-statistic (T_MEAN) and the corresponding *p* value (P_MEAN).

SUDAAN does not test differences in the corresponding totals explicitly. However, it will output the contrast total (TOTAL) and the SE of the contrast total (SETOTAL). With these statistics and the correct degrees of freedom (900 in this example), the *p* value (PVALT) for the test of differences between totals for uncontrolled domains can be calculated as indicated in Exhibit A.5. The SAS function PROBT returns the probability from a *t*-distribution.

Exhibit A.5 SAS Code (Calculation of the *P* Value for the Test of Differences between Totals for Uncontrolled Domains)

```
IF SETOTAL GT 0.0 THEN DO;
   PVALT=2*(1-PROBT(ABS(TOTAL/SETOTAL),900));
END;
```

In the Exhibit A.1 example, all persons (aged 12 or older) and gender are annually controlled totals. For controlled domains like these, additional steps are needed to compute similar *p* values for tests of differences. One approach uses an additional DESCRIPT procedure in SUDAAN to output the appropriate covariance matrix (Exhibit A.6). Then, through further SAS data manipulations, the weighted sample sizes (WSUM), variances, and the covariance of

the two means (obtained from the covariance matrix) are used to generate the standard *t*-test statistic. The corresponding *p* value can once again be produced using the SAS PROBT function and calculated *t*-test statistic.

Exhibit A.6 SUDAAN DESCRIPT Procedure (Covariance Matrix)

```
PROC DESCRIPT DATA=DATANAME DDF=900 DESIGN=WR FILETYPE=SAS DEFT4;
NEST VESTR VEREP;
WEIGHT ANALWT;
VAR ALCMON;
SUBGROUP YEAR IRSEX
LEVELS 2 2;
TABLES IRSEX*YEAR;
PRINT COVMEAN / STYLE = NCHS;
OUTPUT / MEANCOV = DEFAULT REPLACE FILENAME="OUT.SUDCOV";
TITLE "Variance Covariance Matrices ";
RUN;
```

```
Note: The following CLASS statement could be used in place of SUBGROUP
and LEVELS statements in the above example:
      CLASS YEAR IRSEX;
```

The covariances of the estimated means can be obtained from the output of the DESCRIPT procedure (Exhibit A.6). The covariance matrix consists of a row and column for each gender (total, male, female) and year (both years, 2009, and 2010) combination with each cell corresponding to a particular variance component (i.e., a 9 x 9 matrix). Because the rows and columns of the matrix are identical, the cells in the top half (above the diagonal) and the bottom half (below the diagonal) are identical. Below is a shell of what the covariance matrix would look like for this example.

			IRSEX=0			IRSEX=1			IRSEX=2		
			YEAR=0	YEAR=1	YEAR=2	YEAR=0	YEAR=1	YEAR=2	YEAR=0	YEAR=1	YEAR=2
		ROWNUM	B01	B02	B03	B04	B05	B06	B07	B08	B09
	YEAR=0	1									
	YEAR=1	2									
IRSEX=0	YEAR=2	3									
	YEAR=0	4									
	YEAR=1	5									
IRSEX=1	YEAR=2	6									
	YEAR=0	7									
	YEAR=1	8									
IRSEX=2	YEAR=2	9									

In the SUDAAN output, each cell of the variance-covariance matrix is identified by a separate variable of the form B0*x*, where *x* is a particular cell number. (Cells are numbered left to right.) The variable *ROWNUM* is an additional output variable that simply identifies the matrix row. The covariance data needed for a particular significance test can be pulled out of the matrix using SAS code. For this example, the covariance for IRSEX=0 between YEAR=1 and YEAR=2, would be either B03 from ROWNUM2 or B02 from ROWNUM3. These two values would be the same in this case. The needed covariances are kept in the SAS code shown in Exhibit A.7.

The three SAS datasets created by the following examples, one containing the covariances (Exhibit A.7) and two containing the variances (Exhibit A.8), are then merged with the output dataset from the DESCRIPT procedure that generated the tests of differences (Exhibit A.4). With the proper statistics contained in one dataset, the corresponding *p* value for the tests of differences between controlled totals can be produced using the SAS PROBT function and calculated *t*-test statistic (Exhibit A.9).

Exhibit A.7 SAS Code (Identification of Covariance Components)

```
DATA COV(KEEP=IRSEX COV1);
  SET OUT.SUDCOV;
    IF ROWNUM=2 THEN DO; IRSEX=0; COV1=B03; END;
  ELSE IF ROWNUM=8 THEN DO; IRSEX=2; COV1=B09; END;
  ELSE IF ROWNUM=5 THEN DO; IRSEX=1; COV1=B06; END;
  IF ROWNUM IN (2,5,8) THEN OUTPUT;

RUN;

PROC SORT DATA=COV; BY IRSEX; RUN;
```

The variances of the means are calculated in separate data steps shown in Exhibit A.8. The variance is simply the SE of the mean squared. The SE of the means were output in the original DESCRIPT procedure that generated the estimates.

Exhibit A.8 SAS Code (Calculation of Variances)

```
DATA EST1(KEEP=WSUM1 VAR1 YEAR IRSEX);
 SET OUT.SUDFILE;
 WHERE YEAR=1;
 WSUM1=WSUM;
 VAR1=SEMEAN**2; /*THE variance is the SEMEAN squared*/
 RUN;

 DATA EST2(KEEP=WSUM2 VAR2 YEAR IRSEX);
 SET OUT.SUDFILE;
 WHERE YEAR=2;
 WSUM2=WSUM;

RUN;
```

Exhibit A.9 SAS Code (Calculation of the *P* Value for the Test of Differences between Totals for Controlled Domains)

```
      DATA P_VALUE;
       MERGE EST1 EST2 OUT.SUDTESTS COV;
       BY IRSEX;

PVALT=2*(1-PROBT(ABS(TOTAL/SQRT(WSUM1**2*VAR1+WSUM2**2*VAR2-
           2*WSUM1*WSUM2*COV1)),900));

      RUN;
```