Modifying State Sample Sizes for the National Crime Victimization Survey

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Abstract
The National Crime Victimization Survey historically was designed to produce an annual national estimate of crime victimization in the United States. Beginning in 2016, the sample was redesigned and increased to support state-level estimates for the largest 22 states (called "boost states") using three years of data. The national and state-level sample sizes were calculated before data collection began, based on the critical assumption that each state-level estimate would match the national estimate. State-level sample sizes also were calculated assuming a national design effect based on historical survey results. We examine the impact of these assumptions on state-level sample sizes by comparing current sample sizes to ones calculated using state-specific victimization estimates and design effects. We also discuss the various formulas considered when calculating design effects, and the effect of the victimization estimate on them.

Key Words: Sample Size, Design Effect, Sample Design

1. Background

The National Crime Victimization Survey (NCVS) is a nationally representative household survey that collects information on criminal victimization, both reported and not reported to police. Persons at each household or group quarter[1] are interviewed every six months, for a total of up to seven interviews. The NCVS provides national estimates of the number and rate of victimizations in a year for personal and property crime categories. Beginning in 2016, the NCVS sample was redesigned and increased to support subnational estimates for the largest 22 states (called "boost states") using three years of data.

The NCVS uses a two-stage sample design. The first stage of sampling involves defining and selecting counties or groups of bordering counties called Primary Sampling Units (PSUs) and occurs once every 10 years. The PSUs are divided into two groups as either Self-Representing (SR) or Non-Self-Representing (NSR). The SR PSUs are all PSUs within large Core Based Statistical Areas and were selected in the sample with certainty. The NSR PSUs are the remaining PSUs, and similar NSR PSUs were grouped into strata within each state. One PSU was selected from each NSR stratum with probability proportional to the population size. The second stage of sampling involves selecting a systematic random sample of housing units and group quarters within the first stage sample PSUs and occurs annually. For more information on the NCVS sample design, please see the NCVS Technical Documentation (NCVS, 2017).

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[*] Any views expressed are those of the authors and not necessarily those of the U.S. Census Bureau.
[1] Group quarters in-scope for the NCVS generally are facilities for people who are not under formally authorized and supervised care and custody such as dormitories, rooming houses, and religious home dwellings (NCVS, 2017).

The NCVS sample was designed to produce a national one-year estimate of violent crime with a coefficient of variation (CV) of five percent and subnational three-year estimates of violent crime with a CV of 10 percent. The national and state-level sample sizes were calculated based on the critical assumption that each state-level violent crime estimate would match the national estimate of two percent. Sample sizes also were calculated assuming a national design effect based on NCVS data from 1996 to 2010.

Since sample sizes were calculated before data collection began, we want to reevaluate the NCVS sample size based on recent data. We examine the impact of previous sampling assumptions on state-level sample sizes by comparing current sample sizes to ones calculated using state-specific estimates and design effects.

We also discuss the effect of the victimization estimate on the design effects. The NCVS sample originally was designed for a violent crime rate that did not include series crimes. Series crimes are crimes that occur with such frequency that a victim is unable to recall each event in detail. One such example is repeated aggravated assault. Previously these crimes were counted as only one victimization in the final estimate, but current estimates count each series crime incident separately up to a maximum of 10 victimizations. We explore the effect of using estimates including series crimes on the sample size.

2. Methods

We calculated national and state-level sample sizes under two different scenarios:

1. Assuming two percent violent crime rate and using national design effects at national and state level
2. Assuming two percent violent crime rate and using national design effects at national level; using state-specific violent crime rates and design effects from the 2016-2018 NCVS at state level

Scenario 1 corresponds to the methods used previously to calculate sample sizes, and Scenario 2 is the ideal scenario that uses state-specific rates and design effects when adjusting the national sample size to support subnational estimates. Each scenario was repeated for crime rates including series crimes and not including series crimes.

The sample sizes discussed here are the target person interviews in six months of data collection, and not the actual number of households in the NCVS. The target person interviews are used to determine the number of households added yearly to the NCVS sample. Refer to the NCVS Technical Documentation for more information (NCVS, 2017).

The following sections describe the assumptions and methodology used to calculate the sample sizes.

1.1 Design Effects

The design effect is the ratio of the variance of an estimate from a complex sample design to the variance of an estimate from a simple random sample design using the same sample size. The variances of the violent crime rates were calculated using Fay's balanced repeated replication formula (Fay, 1989) with a Fay coefficient of 0.5 and 160 replicate weights. The simple random sampling variance was calculated using the formulas

$$\hat{v}_{SRS}(\hat{p}_{SR}) = \frac{\hat{p}_{SR}(1-\hat{p}_{SR})}{n_{SR}} \; and \; \hat{v}_{SRS}(\hat{p}_{NSR}) = \frac{\hat{p}_{NSR}(1-\hat{p}_{NSR})}{n_{NSR}}$$

where $\hat{p}_{SR}$ and $\hat{p}_{NSR}$ are the SR/NSR crime rates, and n_{SR} and n_{NSR} are the half-year number of completed person interviews in the SR/NSR areas. The number of completed person interviews is for a half-year because persons are generally interviewed twice a year to produce annual estimates.

National one-year design effects were calculated for the SR and NSR strata using an average of the design effects from 2016, 2017, and 2018. National and subnational three-year design effects were calculated by combining the 2016-2018 data together. Design effects were calculated for crime rate estimates including series crimes and not including series crimes. Table 1 summarizes the national one-year and three-year design effects.

Table 1: National One-Year and Three-Year Design Effects

	Including series crimes		*Not including series crimes*	
Estimate	*SR*	*NSR*	*SR*	*NSR*
1-year	4.98	7.22	2.34	2.99
3-year	4.92	6.86	2.34	4.18

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.

The design effects including series crimes are larger than the ones not including series crimes due to the variance of the violent crime rate increasing when series crimes are included. Table 2 summarizes the subnational three-year design effects.

Table 2: Subnational Three-Year Design Effects

	Including series crimes			*Not including series crimes*		
PSU type	*Mean (SD)*	*Min*	*Max*	*Mean (SD)*	*Min*	*Max*
SR	4.96 (2.88)	1.77	11.71	2.14 (0.38)	1.61	2.96
NSR	7.59 (7.92)	0.11	27.11	3.80 (3.28)	0.14	11.50

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.

1.2 National and State-Level Sample Sizes

The national sample size needed to have a violent crime rate with a specific CV was calculated using the formula

$$n = \frac{(1-\hat{p}_{U.S.})}{CV^2\hat{p}_{U.S.}}[W_{SR}deff_{SR} + W_{NSR}deff_{NSR}]$$

where $\hat{p}_{U.S.}$ is the national violent crime rate, W_{SR}/W_{NSR} are the proportion of the population of persons 12 and older in the SR/NSR strata, and $deff_{SR}/deff_{NSR}$ are the national one-year SR/NSR design effects. The national violent crime rate ($\hat{p}_{U.S.}$) was assumed to be 0.02 based on historic NCVS estimates. The W_{SR} and W_{NSR} were about 0.66 and 0.34, respectively, and were based on the population of persons 12 and older in the SR/NSR strata from the 2010 census. After calculating the national sample size, it was allocated proportionally to all 50 states and the District of Columbia based on their 2010 census population.

The sample that was allocated to the 22 boost states was evaluated to see if the sample size was enough to meet the 10 percent CV goal using the formula

$$CV = \frac{\sqrt{v(\hat{p}_k)}}{\hat{p}_k}$$

where $\hat{p}_k$ is the crime rate estimate for state *k* and $v(\hat{p}_k)$ is its variance. Depending on the scenario, the estimated crime rate either was assumed to be the same as the national crime rate in all states (0.02) or was calculated from the 2016-2018 NCVS. The variance was calculated for each boost state using the formula

$$v(\hat{p}_k) = \left(W_{SR,k}\right)^2 \left[deff_{SR,k} \frac{\hat{p}_{SR,k}\left(1-\hat{p}_{SR,k}\right)}{3n_{SR,k}}\right] + \left(W_{NSR,k}\right)^2 \left[deff_{NSR,k} \frac{\hat{p}_{NSR,k}\left(1-\hat{p}_{NSR,k}\right)}{3n_{NSR,k}}\right]$$

where $W_{SR,k}/W_{NSR,k}$ are the proportion of the population 12 and older in state *k* in the SR/NSR strata, $deff_{SR,k}/deff_{NSR,k}$ are the three-year SR/NSR design effects, $\hat{p}_{SR,k}/\hat{p}_{NSR,k}$ are the violent crime rate in the SR/NSR strata, and $n_{SR,k}/n_{NSR,k}$ are the proportionally allocated sample in state *k* in the SR/NSR strata. The design effects and the violent crime rates were either at the national or subnational level, depending on the scenario. The allocated state sample sizes were multiplied by three since the target CV goal is for three years of data.

If the CV of one of the 22 boost states was 0.10 or less, then the sample size in that state was kept the same. Otherwise, the sample size in that state was multiplied by a boost factor *b* that was calculated using the formula

$$b_k = \left(\frac{1}{(0.1\hat{p}_k)^2(3n_k)}\right)\left[W_{SR,k}deff_{SR,k}\hat{p}_{SR,k}\left(1-\hat{p}_{SR,k}\right) + W_{NSR,k}deff_{NSR,k}\hat{p}_{NSR,k}\left(1-\hat{p}_{NSR,k}\right)\right]$$

where n_k is the state sample size before being boosted. As before, the design effects and the violent crime rates were either at the national or subnational level, depending on the scenario.

3. Results

Table 3 and Table 4 compare the sample sizes for Scenario 1 including and not including series crimes to the current sample sizes at different national CV goals. Though the NCVS has a goal of producing national estimates at or below a CV of five percent, the current sample was designed to produce national estimates at or below a CV of 3.68 percent to make the non-boosted national sample size closely resemble the 2000 sample design. As expected, the sample sizes increased as the national CV goal decreased.

Under both national CV goals, the national, boost, and balance sample sizes for Scenario 1 are much larger than the current sample sizes when series crimes are included. This increase is due to the large design effects.

In contrast, the sample sizes for Scenario 1 are smaller than the current when series crimes are not included, except in the balance states when the national CV goal is 3.68 percent. Under this CV goal, the sample size in the balance states is slightly larger than the current size. The difference in the sizes for Scenario 1 without series crimes and the current is not as large as the difference in the sizes for Scenario 1 with series crimes and the current. This smaller difference is because the sample size for Scenario 1 without series crimes was calculated using the same methodology and assumptions as the current sample (especially in Table 4 where the CV goal is the same). However, the size is still different from the current sample for two main reasons. First, the proportion of the sample in the SR and NSR PSUs was not firmly established at time of sample calculation, and thus the proportions previously used were slightly different from how it is in the sample design. Second, the historical design effects used previously are different from the design effects calculated from more recent years.

Table 3: Scenario 1 Sample Sizes (5% CV)

		Scenario 1	
	Current	*With series crimes*	*Without series crimes*
National	144,100	224,600	114,700
Boost states	126,400	201,000	104,100
Balance	17,700	23,600	10,600

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.
Note: Sample sizes rounded to nearest hundred.

Table 4: Scenario 1 Sample Sizes (3.68% CV)

		Scenario 1	
	Current	*With series crimes*	*Without series crimes*
National	144,100	271,900	133,800
Boost states	126,400	228,400	114,400
Balance	17,700	43,600	19,500

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.
Note: Sample sizes rounded to nearest hundred.

Table 5 and Table 6 compare the sample sizes for Scenario 2 including and not including series crimes to the current sample sizes and Scenario 1 at a national CV goal of 3.68 percent. Since the current sample was designed at the 3.68 percent CV goal, we only provide Scenario 2 results at this level. The sample size in the balance states are the same for Scenario 1 and Scenario 2 because the difference in the scenarios occurs when calculating the sample for the boost states (and whether national assumptions or state-specific assumptions are used at this step).

In general, the sample sizes for Scenario 2 are larger than the current sample sizes. One exception is when comparing the current sample sizes to those for Scenario 2 without series crimes; the sample size for Scenario 2 in the boost states is slightly less than the current sample size. However, the national sample size for Scenario 2 still is larger than the current due to the additional sample in the balance states.

The sample sizes for Scenario 2 are also larger than the sample sizes for Scenario 1, both when series crimes are included and not included. Incorporating state-level assumptions

into the sample size calculations increase the overall amount of sample needed in the boost states to meet state-level CV goals.

Table 5: Comparing Sample Sizes for Scenario 2 without Series Crimes (3.68% CV)

	Current	*Scenario 1*	*Scenario 2*
National	144,100	133,800	145,400
Boost states	126,400	114,400	125,900
Balance	17,700	19,500	19,500

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.
Note: Sample sizes rounded to nearest hundred.

Table 6: Comparing Sample Sizes for Scenario 2 with Series Crimes (3.68% CV)

	Current	*Scenario 1*	*Scenario 2*
National	144,100	271,900	275,500
Boost states	126,400	228,400	232,000
Balance	17,700	43,600	43,600

Source: U.S. Census Bureau internal data from the 2016-2018 National Crime Victimization Survey.
Note: Sample sizes rounded to nearest hundred.

4. Conclusion

Sample sizes increase when series crimes are included in the design effects. This increase is because of the larger design effects due to the larger variance in the violent crime rate. In an ideal situation, we would have enough budget to use the sample sizes with series crimes included. Unfortunately, incorporating series crimes into the sample size calculation produces sample sizes that are too large to be feasible.

Sample sizes also increase when using state-specific assumptions instead of only national assumptions. This increase indicates that more sample may be needed to meet state-level NCVS reliability goals. Additionally, sample sizes at the state level vary considerably among the boost states due to the variation in the state-specific crime rates and design effects. It may not be worthwhile having such fluctuation in sample sizes among the states, especially if state-level assumptions change over time.

Due to the recent change in the sample design to include state estimates, this research is limited by the state-level estimates being from only one three-year time period. Waiting until more data are available and averaging the estimates and design effects from the additional data will produce stronger state-level assumptions. We will continue using the current sample sizes and consider revisiting this research after more data are collected in the new sample design.

References

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