AoA SEVENTH NATIONAL SURVEY (2012)

SAMPLE DESIGN, WEIGHTING, AND VARIANCE ESTIMATION

As in previous AoA National Surveys, the seventh national survey will employ a two-stage sample design, first selecting a sample of Area Agencies on Aging (AAAs) in stage one and, in the second stage, a sample of clients for each service within each sampled AAA. The seventh national survey will cover six services – Home Delivered Meals, Homemaker Services, Transportation, the Family Caregiver Support Program, Congregate Meals and Case Management.

Weighting of each service record will be done separately. Initially, base weights will be computed by taking the inverse of the selection probability for each sampled client. Then the base weights will be adjusted for nonresponse, followed by trimming of the extreme weights. Finally, a poststratification adjustment will be made using available population control totals. Fay's modified Balanced Repeated Replication (BRR) method will be used for computation of the sampling variances of survey estimates.

Agency Selection

At the first stage of the two-stage design for the national survey, a stratified sample of approximately 300 AAAs (allowing for a 20% non-response) will be selected from the frame of all agencies. The exact number of agencies on the frame will be determined once the frame has been updated. The sampling frame from the sixth national survey will be used with minor modifications for any changes in the frame reported to Westat. This frame includes the agency measures of size used for the sixth survey. The measures of size were updated in 2011 with new budget figures based on the most recent reports from the AAAs.

The AAA sample will be selected independently within five budget size strata, which are created based on the square root of the total budget sizes of the AAAs. The AAA and client samples will be proportionally allocated to the total of the square root of the budget sizes in each

stratum. However, within a stratum the sample of AAAs will be selected with equal probability, but sorted by Census region. This method has been (and will be) used instead of direct probability proportional to size (PPS) sampling because in the earlier national surveys it was found that budget size was not necessarily well correlated with the total number of clients in each agency for every service. In the absence of any other information, budget size will still be used in sample selection, but with less importance. First, the square root of the budget size (instead of budget size itself) will be used to reduce the effect of large variation in budget sizes. Second, the sample will be allocated at the stratum level proportional to the overall total of the square root of the budget size. This procedure gives a higher probability of selection to agencies with larger budget sizes, but the agencies within a budget size stratum receive the same probability of selection. As in the prior surveys, some agencies will be selected with certainty.

The agencies with the largest budget sizes will be selected with certainty for the AAA sample. The remaining sample will then be selected independently within each of the non-certainty strata. The implicit stratification (sorting) variables in the selection process will be the four Census Regions (Northeast, Midwest, South and West), meaning that the number of agencies in each Region will be selected roughly in proportion to the total of the square root of budget of the Region.

Client Selection

Client samples by service type (Home Delivered Meals, Homemaker, Transportation, Caregiver Service, Congregate Meals, and Case Management) will be drawn randomly within each sampled AAA. The total number of clients receiving each service within an agency will be obtained by contacting either the sampled agencies or the State Unit on Aging (SUA) for the state in which the sampled agency is located before selecting the sample of clients. Based on the total number of clients, line numbers from client master lists will be sampled using a Westat software application that takes the total number of clients in each service by agency and randomly selects the matching line numbers for the selected clients. The number of clients selected from a service within each agency is such that the expected overall probability of selection of a client within a service is roughly the same for all clients within each sampling stratum. Also, to allow for a nonresponse or ineligibility rate (e.g., due to mortality, nursing home placement, or other service termination), the number of clients selected will be increased by the inverse of the rates observed in the previous cycle of the national survey in order to meet the required sample size for each service. In the certainty agencies, the number of clients selected in each agency varies depending

on the budget sizes of the agencies. However, in the non-certainty agencies, fixed-size client samples will be selected from each agency for each service, once the previous survey's client participation rates have been determined.

Selection Probability

The probability of selection of a client within a service can be mathematically expressed as follows. First, let

$P_{i \in h}$ = Probability of selection of agency i in stratum h,

$$= \frac{\text{Number of noncertainty agencies selected from the stratum}}{\text{Total number of noncertainty agencies in the stratum}}$$

$$= \frac{m_h}{M_h}, \text{ for agencies in a non-certainty stratum.}$$

For certainty agencies, the probability of selection is 1 (i.e, $P_{h=c} = 1$). Next, let

P_{ijs} = Probability of selection of client j in service s within agency i,

$$= \frac{\text{Number of clients selected from service } s \text{ in agency } i}{\text{Total number of clients in service } s \text{ in agency } i} = \frac{n_{is}}{N_{is}}.$$

Recall that n_{is} will be fixed in advance for non-certainty agencies by service.

Thus, the overall probability of selection of client j in service s within agency i in stratum h is

$$\pi_{ijs} = P_{i \in h} \times P_{ijs} = \frac{m_h}{M_h} \times \frac{n_{is}}{N_{is}} \quad \text{for the clients within non-certainty agencies,}$$

$$= 1 \times \frac{n_{is}}{N_{is}} = \frac{n_{is}}{N_{is}} \quad \text{for the clients within certainty agencies.}$$

Weighting

Weighting will be done in four steps: calculation of base weights, nonresponse adjustment, trimming of extreme weights, and poststratification adjustments to known population control totals.

Base Weights

The base weight is the inverse of the overall selection probability of a client. The base weight of a client can be obtained by first calculating the base weight for an agency and multiplying that weight by the within-agency-level base weight of a client in a service within that agency.

The base weight for an agency i can be expressed as

$$a_{i,i \in h} = \frac{1}{P_h} = \frac{M_h}{m_h} \qquad \text{for non-certainty agencies,}$$

$$= 1 \qquad \text{for certainty agencies,}$$

and the base weight for a client in a service within an agency can be expressed as

$$v_{ijs} = \frac{1}{P_{ijs}} = \frac{N_{is}}{n_{is}},$$

$$= \text{the within-agency base weight of client } j \text{ in service } s \text{ within agency } i.$$

Therefore, the overall base weight of a client within a service is

$$w_{ijs} = a_i \times v_{ijs} = \frac{1}{\pi_{ijs}},$$

$$= \frac{M_h}{m_h} \times \frac{N_{is}}{n_{is}} \qquad \text{for non-certainty agencies,}$$

$$= 1 \times \frac{N_{is}}{n_{is}} \qquad \text{for certainty agencies.}$$

Nonresponse Adjustment

Since not all sampled agencies and clients are likely to respond to the survey, Westat will plan to adjust the base weights for nonresponse. The nonresponse adjustment will be done in two steps by performing separate adjustments for agency-level and client-level nonresponse.

If m_{hs}^r denotes the number of agencies in stratum h that respond to the survey for service s, then the agency-level nonresponse adjustment is calculated as follows:

$$a_{is,i\in h}^r = \frac{M_h}{m_h} \times \frac{m_h}{m_{hs}^r} = \frac{M_h}{m_{hs}^r}$$

= the nonresponse adjusted weight of agency i for service s.

If n_{is}^r denotes the number of clients that respond for service s within agency i, then the client-level nonresponse adjustment is calculated as follows:

$$v_{ijs}^r = \frac{N_{is}}{n_{is}} \times \frac{n_{is}}{n_{is}^r} = \frac{N_{is}}{n_{is}^r},$$

= the nonresponse adjusted weight for client j for service s within agency i.

Therefore, the overall nonresponse-adjusted weight of client j for service s within agency i is

$$w_{ijs}^r = a_{is}^r \times v_{is}^r = \frac{M_h}{m_{hs}^r} \times \frac{N_{is}}{n_{is}^r}.$$

Trimming of Weights

To keep the variance of the survey estimates within an acceptable level, extreme weights will be trimmed. The sample design was set up to select clients within a service with equal probability so that the base weights of all clients within a service would be roughly equal. This would be the case if the measure of size used in selecting the agencies (i.e., the square root of each agency's annual budget) was perfectly correlated with the number of clients in a service group, and if there were no nonresponse. But in reality, this correlation is not high, and some nonresponse is likely. Some agencies have larger budgets due to larger client sizes in some services but smaller numbers of clients in other services. Similarly, some agencies have smaller budgets but relatively larger numbers of clients in a particular service. This contributes to increased variability in the selection probabilities and subsequently in the base weights. Moreover, the variability in weights can be increased further due to the adjustment of client nonresponse rates that may vary substantially from agency to agency. Since variability in the weights increases the variances of the survey estimates, those weights which are too high

compared to the median base weight will be trimmed to upper acceptable limits to reduce the variance of the weights.

Initially, the upper acceptable limits will be determined by using the median base weight within a service group. Once the weights have been calculated, the distributions of the weights will be analyzed to determine the most appropriate method for trimming, if trimming is needed. One effect of trimming weights is that estimated totals are reduced from what they would have been, had trimming not been applied to the weights. This loss in the sum of weights due to the trimming will be adjusted in the poststratification step described below. The trimmed, nonresponse adjusted weights will be denoted by w_{ijs}^{θ} in the following sections.

Poststratification Adjustment

The final step of weighting will include the benchmarking of the estimated number of clients in a service (based on the trimmed, nonresponse-adjusted weights) to the known total number of clients (population control total) obtained from the AoA State Program Reports (SPR). The poststratification adjustment, or benchmarking, will be done at the regional level, since reliable control totals are assumed to be available at the regional level, as they have been in the past.

The post-stratified weights (w_{ijs}^{p}) for service s are calculated by multiplying the trimmed, nonresponse-adjusted weights (w_{ijs}^{θ}) by the ratio of the known control total (N_s) to the estimated total $(\sum_{ij} w_{ijs}^{\theta})$ as follows:

$$w_{ijs}^{p} = w_{ijs}^{\theta} \times \frac{N_s}{\sum_{ij} W_{ijs}^{\theta}}$$

The poststratification adjustment described in this section will be applied to Home-delivered Meals, Homemaker Services, Congregate Meals and Case Management. Based on prior survey experience, the adjustments for Caregiver and Transportation services are expected to be calculated somewhat differently and are described below.

Poststratification Adjustment for Caregiver Service

The mathematical details for the poststratification adjustment of Caregiver services are identical to those described in the paragraphs immediately above. However, two different sets of control totals are expected to be made available for Caregiver services and hence two different

sets of weights will be created. First, caregiver clients are divided into three groups according to which particular caregiver service the client received: Respite Care, Counseling, or Total Supplemental Services. A separate set of post-stratified weights will be created for each of these three subgroups **to be applied only to those clients receiving that particular service.** This will be done so that weighted totals would be forced to equal the total reported number of clients receiving Respite, Counseling and Supplemental services, respectively. The weights produced by these calculations should be applied only to the individual subgroups of clients (Respite, Counseling and Supplemental) receiving those individual services.

In addition, a set of control totals for **all caregiver recipients combined** will be applied to the entire sample of caregiver clients surveyed. Since a given client could have received any of the three sub-categories of service described in the previous paragraphs, the subgroup totals will be randomly allocated to the subgroups so that those clients who received more than one of the subgroup services will not be overestimated in the overall total. The weights produced by this procedure should be used to produce any estimates for the total group of caregiver clients combined. **The data user must use caution to ensure that the correct set of post-stratified weights is used in making estimates for caregiver clients.**

Poststratification Adjustment for Transportation Service

For the Transportation service, control totals for the number of clients have not previously been available. However, State Units on Aging (SUAs) did provide the number of one-way passenger trips in the State Program Reports (SPR). These SPR regional level trip counts were used in the past for the purpose of estimating control totals for the number of clients receiving transportation services by region. Westat expects to follow the same procedure for Survey 7. The following summarizes the methodology previously used for constructing these transportation client counts:

- The national survey asked respondents how many one-way trips per month they usually took using the AAA transportation service. To ensure proper identification of AAA-funded transportation programs, the computer assisted telephone interviewing (CATI) software allowed the interviewers to prompt the respondents with the specific name of the transportation service, which the provider had supplied to Westat during the client sampling stage.

- An average annual per-person trip count by region was estimated from the survey data file using the trimmed, nonresponse-adjusted weights.

- By dividing the total trip count by the per-person average annual number of trips, Westat estimated the total number of persons who received transportation services by region.

The method of estimation explained above can be mathematically expressed as follows:

$$\hat{N}_s = \sum_g \hat{N}_{gs} = \sum_g \frac{T_g}{\bar{t}_g} = \sum_g \frac{T_g}{\dfrac{\sum\limits_{ij} t_{ij} w_{ijs}^{\theta}}{\sum\limits_{ij} w_{ijs}^{\theta}}} = \sum_g \frac{T_g}{\hat{T}_{gw}} \times \hat{N}_{gw},$$

where

$\hat{N}_s$ is the final estimate of transportation client count,

$\hat{N}_{gs}$ is the final estimate of transportation client count in region g,

T_g is the total number of one-way trips reported by the SUAs in region g,

$\bar{t}_g = \dfrac{\sum\limits_{ij, i \in g} t_{ij} w_{ijs}^{\theta}}{\sum\limits_{ij, i \in g} w_{ijs}^{\theta}}$ is the per-person weighted average of annual number of trips in region g,

t_{ij} is the number of annual one-way trips made by client j in agency i,

$\hat{T}_{gw} = \sum\limits_{ij, i \in g} t_{ij} w_{ijs}^{\theta}$ is an initial estimate of the total number of one-way trips in region g based on the trimmed, nonresponse-adjusted weights;

$\hat{N}_{gw} = \sum\limits_{ij, i \in g} w_{ijs}^{\theta}$ is an initial estimate of the total number of transportation clients

in region g based on the trimmed, nonresponse-adjusted weights.

The above estimator is widely known as a *Ratio Estimator* in the sample survey literature because the initial estimate of the total number of transportation clients ($\hat{N}_w$) is adjusted by the ratio of actual to estimated total number of one-way trips ($\dfrac{T}{\hat{T}_w}$).

Variance Estimation

Westat routinely uses replication-based variance estimation methods for computing sampling variances of the survey estimates derived from complex multi-stage sample designs. Westat's variance computation software, WesVar, is designed for this purpose. A version of balanced repeated replication (BRR) referred to as "Fay's method" will be used to calculate the variances (and their square roots, the standard errors) of estimates derived from the AoA national survey. Implementation of BRR methods for variance estimation requires the use of a series of "replicate weights," each of which provides an alternative (replicate-specific) estimate of a characteristic of interest. The variability of the replicate estimates about the full-sample estimate of the same characteristic is then used to obtain the variance or standard error of the characteristic.

Let y_{ij} denote a survey characteristic (variable) for the jth respondent in the ith agency, and let w_{ij}^p denote the corresponding full-sample final weight. Further, let w_{ij}^k denote the kth replicate weight, where $k = 1, 2, ..., K$. The estimated total for the survey variable is given by the weighted sum

$$\hat{y} = \sum_{ij} w_{ij}^p y_{ij} \ .$$

The corresponding replicate estimates are given by the weighted sums

$$\hat{y}_k = \sum_{ij} w_{ij}^k y_{ij} \ , \text{ for } k = 1, 2, ..., K$$

The variance of the estimator $\hat{y}$ is then computed as:

$$\text{var}(\hat{y}) = \frac{1}{(1-.30)^2} \sum_{k=1}^{K} (\hat{y}_k - \hat{y})^2 \ ,$$

where the 0.30 in the above formula is referred to as "Fay's factor." The corresponding standard error is simply the square root of $\text{var}(\hat{y})$ as computed above.

The replicate weights, w_{ij}^k, required for variance estimation will be derived from replicate-specific base weights and include all of the adjustments (e.g., nonresponse and poststratification) used to develop the full-sample weights, w_{ij}^p.

Replicates will be formed first by creating variance strata and variance units. For non-certainty AAAs, variance strata will be formed with two or three AAAs in each stratum, and each AAA will be treated as a variance unit. For certainty AAAs, each AAA will be treated as a variance stratum, and random groups of clients will be formed as variance units within the stratum. This difference in forming variance strata for certainty and non-certainty AAAs is necessary to account for the fact that there is no first stage sampling variance for certainty AAAs. Under BRR, the replicates are formed in a balanced way by taking one variance unit from each variance stratum. However, a modified version of BRR called Fay's method will be used for the AoA survey. Under the modified approach, the full-sample weights are adjusted or "perturbed" to define the required replicates, rather than taking one variance unit from each stratum. Further details on BRR and Fay's method, or replication methods in general, can be found in the WesVar 5.0 User's Guide, (www.Westat.com).

WesVar, SUDAAN, STATA, SAS and other complex sample survey software packages can use replicate weights to compute variance estimates that fully account for the complex design used in the AoA national surveys.