An Introduction to the SAS® Survey Analysis PROCs

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Abstract

This paper provides an introductory overview of the SAS survey analysis PROCS: SURVEYMEANS, SURVEYFREQ, SURVEYLOGISTIC and SURVEYREG. For all procedures we will discuss the STRATA, CLUSTER and WEIGHT statements with respect to specifying the sample design and generating weighted estimates. We will also discuss the importance of not deleting observations in order to analyze subpopulations, as well as analyzing data with missing values. Other PROC-specific statements will be discussed, e.g. TABLES in SURVEYFREQ, DOMAIN in SURVEYMEANS and MODEL in SURVEYLOGISTIC. In addition we will briefly discuss the Taylor linearization method for variance estimation used by SAS and how SAS (by default) handles situations where there is only one cluster in a stratum. Concrete examples will be used (with SAS 9.1.3). This paper will be of interest to SAS programmers who need to analyze the results of complex, i.e. not simple, random, surveys.

Introduction

Before the introduction of the survey procedures, SAS could not be used for variance estimation with complex survey data because the existing statistical procedures, e.g. FREQ, MEANS, did not have the functionality for incorporating the design properties of complex surveys into the analysis, i.e. they assumed the design to be a simple random sample of an infinite population. In our experience this assumption generally leads to an underestimation of variance. This introductory paper will not answer all the questions you may have about using SAS for analyzing complex surveys, but we hope that reading this paper will put you in a better position to know what questions to ask when you first need to use a SAS survey procedure,

For a paper on variance estimation, this paper has a notable lack of statistical formulae. This is because we have targeted SAS programmers rather than statisticians. We have taken a 'functional' approach to discussing the survey procedures. The SAS documentation contains excellent discussions of the statistical details which are built into the respective procedures.

Variance Estimation with Complex Surveys

A complex survey design is any design that is not a simple random sample (where each person in the target population has an equal chance of being selected in the survey). Complex designs involve dividing the population into groups and sampling the groups themselves (cluster sampling) and/or sampling from the groups (stratified sampling).

In SAS 9.1.3 the only available method for variance estimation is Taylor linearization. Replication methods (e.g. jackknife and balanced repeated measures) are available in SAS 9.2 but will not be discussed in this paper (but see Mukhopadhyay *et al*, 2008).

One important point to emphasize when analyzing data from complex surveys is that you should resist the normally efficient practice of subsetting to just those records that will be used in the analysis. This subverts the process of giving the procedures all the necessary survey design information with respect to strata and clusters. That is, if you are interested in a particular analysis of city-dwellers within a nationally-representative survey and subset to just this subpopulation before your analysis, you may be deleting information about the full design properties of the survey. You are more or less likely to do this depending on the criteria for subsetting. For example, subsetting to males from a typical national survey population is unlikely to exclude all records in a particular PSU and remove it from the analysis (and if it did you'd really want to know why!). Below we discuss the DOMAIN option for analyzing subpopulations within a sample population. Examples are shown for PROCs SURVEYMEANS and SURVEYLOGISTIC.

All examples used in this paper use as input the Medical Expenditure Panel Survey (MEPS), discussed in the next section. No matter what data source is used as input, correct variance estimation for complex survey data requires knowing the design properties of the survey being analyzed.

The Household Component of the Medical Expenditure Panel Survey (MEPS HC)

The MEPS HC is a nationally representative survey of the U.S. civilian noninstitutionalized population. It collects medical expenditure data as well as information on demographic characteristics, access to health care, health insurance coverage, as well as income and employment data. MEPS is cosponsored by the Agency for Healthcare Research and Quality (AHRQ) and the National Center for Health Statistics (NCHS). For the comparisons reported here we used the MEPS 2005 Full Year Consolidated Data File (HC-097). This is a public use file available for download from the MEPS web site (http://www.meps.ahrq.gov). See also the MEPS Factsheet "Computing Standard Errors for MEPS Estimates", also available from the MEPS web site.

The MEPS is not a simple random sample, its design includes stratification, clustering, multiple stages of selection, as well as disproportionate sampling. The MEPS public use files (such as HC-097) include variables for generating weighted national estimates and for use of the Taylor method for variance estimation. These variables are: person-level weight (PERWT05F on HC-097); stratum (VARSTR on HC-097); and cluster/psu (VARPSU on HC-097).

PROC SURVEYMEANS

In this section we will first review the basic syntax of SURVEYMEANS. We will then generate some estimates and standard deviations and errors using the 2005 MEPS full year file (HC-097). Note that we used SAS 9.1.3 for the comparisons reported here.

SYNTAX

The following illustrates the relevant syntax and statements for PROC SURVEYMEANS:

```
(1)     PROC SURVEYMEANS DATA= HC097 SUM STD MEAN STDERR;
              STRATA VARSTR / LIST;
              CLUSTER VARPSU;
              WEIGHT PERWT05F;
              VAR TOTEXP05;
        RUN;
```

The options selected on the PROC SURVEYMEANS statement are SUM, STD (standard deviation of the sum), MEAN, and STDERR (standard error of the mean). The STRATA statement (you can also use "STRATUM" when you have one variable and you're fussy about your Latin) is where you list the strata variables if you have a stratified sample. The LIST option causes SAS to generate a *Stratum Information* table which lists the variables and sampling rates for each stratum, as well as the number of records and clusters for each stratum and analysis variable. This can be very handy information. For example, for the MEPS HC-097 file the Stratum

Information table shows that each stratum has at least 2 PSUs (clusters). The head of this table shows the following information.

```
(2)    Number of Strata                                      203
       Number of Clusters                                    452
       Number of Observations                              33961
       Number of Observations Used                         32320
       Number of Obs with Nonpositive Weights               1641
       Sum of Weights                                  296185002
```

The 1,641 records with non-positive weights are excluded prior to analysis. The N value that appears in the LST output will be 32,320 (number of observations used). For TOTEXP05 the NMISS value will be zero because all records have a non-missing value for this analysis variable.

The CLUSTER statement is where (you guessed it!) you list the cluster variables. For MEPS (as with all stratified samples), clusters are nested within strata.

This may be obvious but it's worth pointing out that SAS will not tell you the sample design of the data you're working with. You need to know the design of the survey that produced the data and how those design properties are to be specified in the survey procedures. The Federal agencies responsible for distributing public use files for data such as the MEPS do an excellent job of providing documentation of survey design and data file properties.

The WEIGHT statement is self-explanatory. Records with nonpositive or missing weight values are excluded from the analysis.

The VAR statement lists the analysis variables. Here TOTEXP05 is the 2005 MEPS total expenditure variable. The HC-097ile is a person-level file with 33,961cords. All records have a non-missing value for TOTEXP05 This is consistent with the situation described in (1a): all survey respondents are in the analytic population and all have a non-missing value for the analysis variable.

When we run (1) SAS generates the following output statistics (rounded values are given). The full output listing is given in the Appendix.

```
(3)    SUM:      1,023,763,462,950
       STD:         33,630,954,198
       MEAN:                 3,457
       STDERR:                   90
```

If we run (2) but omit the STRATA and CLUSTER statements, SAS generates the same SUM and MEAN, but the standard deviation and standard error are those given in the parentheses in (4).

```
(4)    SUM:      1,023,763,462,950
       STD:         33,630,954,198 (23,916,914,371)
       MEAN:                  3,457
       STDERR:                   90 (79)
```

This comparison is consistent with our general experience that variance estimation where a simple random sample is assumed underestimates standard deviations and standard errors for complex samples.

DOMAIN (Subgroup) Analysis

In this section we show the use of the SURVEYMEAN's DOMAIN statement. We will compute the mean and standard error again for the MEPS TOTEXP01 variable, but here we will also look at males and females as subgroups.

(5)

```
PROC SURVEYMEANS DATA= HC097 MEAN STDERR;
      STRATA VARSTR;
      CLUSTER VARPSU;
      WEIGHT PERWT05F;
      VAR TOTEXP05;
      DOMAIN SEX;
RUN;
```

The DOMAIN statement shows the categorical variable SEX. The output statistics are shown in (6).

(6)

```
                                   Data Summary

                          Number of Strata                                203
                          Number of Clusters                              452
                          Number of Observations                        33961
                          Number of Observations Used                   32320
                          Number of Obs with Nonpositive Weights         1641
                          Sum of Weights                            296185002


                                                  Statistics

                                                                    Std Error
           Variable                 N          N Miss          Mean     of Mean
           ------------------------------------------------------------------------
           TOTEXP01            32320                0   3456.500008   90.433709
           ------------------------------------------------------------------------


                                            Domain Analysis: SEX

                                                                                Std Error
           SEX       Variable           N          N Miss            Mean         of Mean
           -----------------------------------------------------------------------------
           FEMALE    TOTEXP05       15251               0     2954.576843      105.916815
           MALE      TOTEXP05       17069               0     3938.646448      135.136809
           -----------------------------------------------------------------------------
```

Missing Values for the Analysis Variable (one PSU in some strata)

In this section we will first look at an example where records with missing values for the analysis variable create a situation where some strata only have one PSU (cluster) per stratum. We create this example by modifying the MEPS example from the previous section so we can run an analysis just for expenses paid by Medicare (the MEPS variable TOTMCR05). Further, for this analysis we are interested in computing the mean only for those persons with a workers' compensation expense, i..e. zero values are set to missing.

(7)
```
PROC SURVEYMEANS DATA= HC097 MEAN STDERR;
     STRATA VARSTR / LIST;
     CLUSTER VARPSU;
     WEIGHT PERWT05F;
     VAR TOTMCR05;
RUN;
```

Running (7) generates the LOG note in (8) and the output statistics in (9):

(8)
```
Only one cluster in a stratum for variable TOTWCP05.  The variance in
that stratum is estimated by zero.
```

(9)
```
MEAN:                    5331.97
STDERR:                   255.53
```

The stratum information table would also show which of the strata have only one cluster (PSU). The NMISS value on the output statistics would be 28,168 and the N would be 4,152. NMISS indicates the number of records with a positive weight that have a missing value for the analysis variable TOTMCR05.

Note that if you run this type of analysis in a software package such as SUDAAN (using the default Taylor linearrization method settings), the generated standard error will be different. The reason for the difference in standard error values is the different assumptions made by SAS and SUDAAN concerning the treatment of missing values (see SAS FAQ # 1813 available online at SAS Technical Support). SAS survey analysis procedures assume that missing values for analysis variables are missing completely at random and delete them before running the analysis. In contrast, the SUDAAN default analysis assumes that these values are not missing completely at random and runs a domain analysis focused only on those records with non-missing values, i.e. the subset (or, domain) of respondents for the analysis variable. Note that this is a distinct situation from what we saw in the previous section. Here (as the stratum information table would show) all strata have at least 2 clusters.

We can simulate this approach in SURVEYMEANS by using the DOMAIN statement to explicitly distinguish missing and non-missing values for the analysis variable. First we need to create a categorical variable INDICATOR (see also the SURVEYMEANS documentation for analyzing data with missing values). Then we can run SURVEYMEANS with the code in (11).

(10)
```
DATA HC097I;
     SET HC097;
     IF TOTMCR05 GT 0
          THEN INDICATOR = 'NOT_MISSING';
     ELSE INDICATOR = 'MISSING';
RUN;
```

(11)
```
PROC SURVEYMEANS DATA= HC097I;
     STRATA VARSTR ;
     CLUSTER VARPSU;
     WEIGHT PERWT05F;
     VAR TOTMCR05;
     DOMAIN INDICATOR;
RUN;
```

This will produce the output in (12).

```
                                   Statistics

                                                                Std Error
Variable                 N            N Miss              Mean        of Mean
--------------------------------------------------------------------------
TOTMCR05              4152             28168       5331.970280     255.529494
--------------------------------------------------------------------------


                           Domain Analysis: INDICATOR

                                                                                 Std Error
INDICATOR      Variable                 N            N Miss              Mean        of Mean
------------------------------------------------------------------------------------------
MISSING        TOTMCR05                 0             28168                 .              .
NOT_MISSING    TOTMCR05              4152                 0       5331.970280     255.424552
------------------------------------------------------------------------------------------
```

The standard error in the first statistics row is the one SURVEYMEANS computes for the mean under the assumption that missing values are missing completely at random. The domain analysis section shows the standard error produced by the 'indicator' approach. The value of 255.424552 is exactly what is produced by SUDAAN's PROC DESCRIPT. Although intuitively the numeric difference between the two values is not great, it is important to understand that (i) the default assumptions which underlie the computation of standard errors in cases where there are cluster-level missing values, and (ii) that SURVEYMEANS, through the use of the DOMAIN statement, offers a way to incorporate into the analysis the non-default assumption that missing values are not missing completely at random.

The documentation for SURVEYMEANS lists the various keywords to be used for requesting additional statistical output, e.g. confidence limits for the mean or sum; coefficient of variation for the mean or sum. For example, the RATIO statement requests ratio analysis for means or proportions of analysis variables. These variables must also be listed on the VAR statement.

PROC SURVEYFREQ

If you are familiar with PROC FREQ then you have a clear jumpstart on using SURVEYFREQ. In addition to the STRATA and CLUSTER statements, which have the same function we discussed for SURVEYMEANBS, the TABLES, WEIGHT and FORMAT statements operate in a similar fashion to PROC FREQ. Example (13) shows a typical two-way frequency.

```
(13)    PROC SURVEYFREQ DATA= HC097;
              TABLES HISPANX*INSCOV05;
              STRATA VARSTR;
              CLUSTER VARPSU;
              WEIGHT PERWT05F;
              FORMAT HISPANX HISPF. INSCOV05 INSF. ;
        RUN;
```

Here the variables on the TABLES statement are HISPANX (a demographic variable indicating self-reported race/ethnicity), and INSCOV05 (a variable indicating insurance status in 2005). The output of (13) is given in (14).

(14)

```
                                The SURVEYFREQ Procedure

                                             Data Summary

                          Number of Strata                                 203
                          Number of Clusters                               452
                          Number of Observations                         33961
                          Number of Observations Used                    32320
                          Number of Obs with Nonpositive Weights          1641
                          Sum of Weights                             296185002


                                    Table of HISPANX by INSCOV05

                                                 Weighted    Std Dev of                 Std Err of
 HISPANX        INSCOV05       Frequency        Frequency      Wgt Freq      Percent       Percent
------------------------------------------------------------------------------------------
HISPANIC     ANY PRIVATE            2887         18908300       1242584       6.3839        0.3674
             PUBLIC ONLY            3512         12877938        733805       4.3479        0.2273
               UNINSURED            2591         11790097        825434       3.9807        0.2465

                   Total            8990         43576335       2417073      14.7125        0.6899
------------------------------------------------------------------------------------------
   BLACK     ANY PRIVATE           15423        186356680       4857520      62.9190        0.7401
             PUBLIC ONLY            5401         41413223       1445538      13.9822        0.3970
               UNINSURED            2506         24838765        932800       8.3862        0.2512

                   Total           23330        252608667       6097607      85.2875        0.6899
------------------------------------------------------------------------------------------
   Total     ANY PRIVATE           18310        205264979       5264787      69.3030        0.5957
             PUBLIC ONLY            8913         54291161       1755404      18.3302        0.4523
               UNINSURED            5097         36628862       1371767      12.3669        0.3297

                   Total           32320        296185002       7072820      100.000
------------------------------------------------------------------------------------------
```

One advantage of the default SURVEYFREQ output is that the table shows both unweighted and weighted frequencies. This was not possible with PROC FREQ, where you had to run the PROC with and without the WEIGHT statement to generate both frequencies.

There are a number of TABLES statement options for selecting different output. For example, if you want to generate confidence limits for weighted frequencies, you can use the CLWT option. In (15) below we illustrate the ROW option. The ouput is shown in (16).

(15)

```
PROC SURVEYFREQ DATA= HC097;
      TABLES HISPANX*INSCOV05 / ROW;
      STRATA VARSTR;
      CLUSTER VARPSU;
      WEIGHT PERWT05F;
      FORMAT HISPANX HISPF. INSCOV05 INSF. ;
RUN;
```

(16)

```
                                        The SURVEYFREQ Procedure

                                              Data Summary

                                 Number of Strata                                 203
                                 Number of Clusters                               452
                                 Number of Observations                         33961
                                 Number of Observations Used                    32320
                                 Number of Obs with Nonpositive Weights          1641
                                 Sum of Weights                             296185002


                                         Table of HISPANX by INSCOV05

                                             Weighted    Std Dev of               Std Err of         Row     Std Err of
HISPANX         INSCOV05     Frequency      Frequency      Wgt Freq     Percent      Percent     Percent    Row Percent
-----------------------------------------------------------------------------------------------------------------------
HISPANIC    ANY PRIVATE           2887       18908300       1242584      6.3839       0.3674     43.3912         1.3001
            PUBLIC ONLY           3512       12877938        733805      4.3479       0.2273     29.5526         1.1133
              UNINSURED           2591       11790097        825434      3.9807       0.2465     27.0562         0.8611

                  Total           8990       43576335       2417073     14.7125       0.6899     100.000
-----------------------------------------------------------------------------------------------------------------------
   BLACK    ANY PRIVATE          15423      186356680       4857520     62.9190       0.7401     73.7729         0.5635
            PUBLIC ONLY           5401       41413223       1445538     13.9822       0.3970     16.3942         0.4533
              UNINSURED           2506       24838765        932800      8.3862       0.2512      9.8329         0.2952

                  Total          23330      252608667       6097607     85.2875       0.6899     100.000
 -----------------------------------------------------------------------------------------------------------------------
   Total    ANY PRIVATE          18310      205264979       5264787     69.3030       0.5957
            PUBLIC ONLY           8913       54291161       1755404     18.3302       0.4523
              UNINSURED           5097       36628862       1371767     12.3669       0.3297

                  Total          32320      296185002       7072820     100.000
 -----------------------------------------------------------------------------------------------------------------------
```

In (16), in addition to the frequencies shown in (14), the use of the ROW option causes SAS to output within-group percent estimates in the "Row Percent" column (the SEs for these estimates are shown in the "Std Err of Row Percent" column). For example, the first row of the table in (16), the "Percent" column shows that about 6.3% of the total population is Hispanic with Any Private insurance. The "Row Percent" column shows that about 43.3% of the Hispanic population has Any Private insurance.

The documentation for SURVEYFREQ shows additional options for requesting statistical tests (e.g. chi-square tests) and output (e.g. variances for weighted frequencies). Options for suppressing output (e.g. NOPERCENT, NOPRINT) are also listed.

PROC SURVEYLOGISTIC

In this section we will first review the basic syntax of PROC SURVEYLOGISTIC. We will then discuss selected options and statements.

The STRATA and CLUSTER statements should be familiar by now, as are the WEIGHT and FORMAT statements.

In the model below, the dependent variable is DENTAL_VISIT a binary variable indicating a visit to a dentist's office in 2005 (1= YES, 2 = NO). This variable is based on the MEPS variable DVTOT05, a count of number of dental visits in 2005. The independent variables are: POVCAT05, a categorical variable with 5 values indicating poverty status (1= POOR – 5= HIGH INCOME); and INSCOV05, a categorical variable with three values indicating insurance-coverage status (1= ANY PRIVATE, 2= PUBLIC ONLY, 3= UNINSURED). INSCOV05 was used in the SURVEYFREQ examples above.

```
(17)    PROC SURVEYLOGISTIC DATA=MEPS_H97;
             STRATA VARSTR;
             CLUSTER VARPSU;
             WEIGHT PERWT05F;
             CLASS POVCAT05 INSCOV05 (REF='1 ANY PRIVATE')
                   / PARAM=REF ORDER=INTERNAL;
             MODEL DENTAL_VISIT (EVENT='1')= POVCAT05 INSCOV05/VADJUST=NONE;
             CONTRAST "Test poor, Near poor, and low income versus
                   Middle income" POVCAT05 0  0.5  0.5  -1  0 ;
             FORMAT  INSCOV05 INSCV05F. POVCAT05 POVCAT.;
        RUN;
```

For the CLASS statement, the PARAM=REF (reference) option overrides the default PARAM=EFFECT. When using the reference method, the highest variable value is, by default, used as reference. This can be changed by the REF= option, as shown in (17). Here default reference for INSCOV05 would be '3 UNINSURED'. This is changed to '1 ANY PRIVATE' in the example.

Note also that, when the FORMAT statement is used, the SAS default is ORDER=FORMATTED. Here this is changed to ORDER=INTERNAL, i.e. unformatted.

The MODEL option EVENT= specifies the event category for the binary variable DENTAL_VISIT. The specification EVENT='1' specifies '1' as the event category value. By default, SURVEYLOGISTIC models the lowest value. The option VADJUST=NONE is used to suppress any variance adjustment associated with the Wald test. Adjusting by degrees of freedom (VADJUST = DF) is the default.

The CONTRAST statement (which must appear after the MODEL statement) tests the hypothesis that the combined poor/near poor/low income group is different from the middle income group. The ouput generated by this statement is shown in (18).

(18)

```
 Contrast Test Results

 Contrast                                  DF     Wald Chi-Square     Pr > ChiSq
 ------------------------------------------------------------------------------

 Test Negative/poor, Near poor, and
 low income versus middle income            1              35.517         <.0001
```

PROC SURVEYLOGISTIC outputs 11 tables by default. Here we will illustrate the ODS statements necessary for outputting the subset of these you may be interested in. One prerequisite to using the ODS statement is knowing the names of the output tables (e.g. ODDSRATIOS and PARAMETERESTIMATES in (19)). Using the ODS TRACE ON/OFF statements before and after the program code for the relevant procedure will output these table names to the LOG. Table names are also listed with the procedure documentation.

By adding the following ODS statement to the PROC SURVEYLOGISTIC above, two permanent SAS data sets, Dent_Care_Odds and Denta_Care_Beta, are output to the OUT directory. ODDSRATIOS and PARAMETERESTIMATES are table names defined by SAS.

```
(19)    ODS OUTPUT ODDSRATIOS    = OUT.DENT_CARE_ODDS
                   PARAMETERESTIMATES = OUT.DENT_CARE_BETA;
```

The output below is from the output datasets DENT_VISIT_ODDS and DENT_VISIT_ODDS.

(20) DENT_VISIT_BETA

Variable	ClassVal0	DF	Estimate	StdErr	WaldChiSq	ProbChiSq
Intercept		1	0.367	0.035	111.120	5.57E-26
POVCAT05	1 POOR/NEGATIVE	1	-0.870	0.064	183.497	8.36E-42
POVCAT05	2 NEAR POOR	1	-0.966	0.090	114.868	8.41E-27
POVCAT05	3 LOW INCOME	1	-0.839	0.059	200.187	1.90E-45
POVCAT05	4 MIDDLE INCOME	1	-0.520	0.046	128.661	8.04E-30
INSCOV05	2 PUBLIC ONLY	1	-0.429	0.054	63.944	1.28E-15
INSCOV05	3 UNINSURED	1	-1.356	0.067	411.707	1.56E-91

(21) DENT_CARE_ODDS

Effect	OddsRatioEst	LowerCL	UpperCL
POVCAT05 1 POOR/NEGATIVE vs 5 HIGH INCOME	0.419	0.369	0.475
POVCAT05 2 NEAR POOR vs 5 HIGH INCOME	0.380	0.319	0.454
POVCAT05 3 LOW INCOME vs 5 HIGH INCOME	0.432	0.385	0.486
POVCAT05 4 MIDDLE INCOME vs 5 HIGH INCOME	0.594	0.543	0.650
INSCOV05 2 PUBLIC ONLY vs 1 ANY PRIVATE	0.651	0.586	0.723

As discussed above with PROC SURVEYMEANS, the DOMAIN statement should be used for subpopulation, or domain analysis. The formation of these domains may be unrelated to the sample design. Therefore, the sample sizes for the domains are random variables. Domain incorporates this variability into the variance estimation.

The DOMAIN statement is different than a BY statement. The BY statement treats the sample sizes as fixed in each subpopulation, subsets the input data to each subpopulation group, and perform analysis within each BY group separately. If the subpopulation do not include all strata and clusters (PSUs), the BY statement uses fewer degree of freedom for significance testing.

The code below would analyze how dental visits are associated with family income for each insurance category (DOMAIN INSCOV05). The output for this is not shown.

```
(22)    PROC SURVEYLOGISTIC DATA=MEPS_H97;
           STRATA VARSTR;
           CLUSTER VARPSU;
           WEIGHT PERWT05F;
           DOMAIN INSCOV05;
           CLASS POVCAT05 INSCOV05 (REF='1') /PARAM=REF ORDER=INTERNAL;
           MODEL DENTAL_VISIT (EVENT= '1') = POVCAT05/VADJUST=NONE;
        RUN;
```

PROC SURVEYREG

The SURVEYREG procedure performs regression analysis for sample survey data. The procedure fits linear models for survey data and computes regression coefficients and their variance-covariance matrix. The procedure also provides significance tests for the model effects and for any specified estimable linear functions of the model parameters. Using the regression model, the procedure can compute predicted values for the sample survey data.

The example below uses the MEPS data to illustrate how total dental expenditures are associated with family income and insurance coverage. Variable DVTEXP05 is an expenditure variable indicating the amount spent per person in 2005. The ODS statement requests two output datasets: D_EXP_TEST (from the EFFECTS table) and D_EXP_COEFFICIENTS (from the PARAMETERESTIMATES table). This output is shown in (24) and (25), respectively.

```
(23)    PROC SURVEYREG DATA=MEPS_H97;
              STRATA VARSTR;
              CLUSTER VARPSU;
              WEIGHT PERWT05F;
              CLASS POVCAT05 INSCOV05;
              MODEL  DVTEXP05 = POVCAT05 INSCOV05/SOLUTION;
              CONTRAST "Test low income versus middle income"
                         POVCAT05 0 0 1 -1 0;
              ODS OUTPUT PARAMETERESTIMATES = out.d_exp_coefficient
                         EFFECTS = Out.D_Exp_test CONTRASTS = Econtrast;
        RUN;
```

As we have seen in previous examples, the poverty-status (POVCAT05) and insurance-coverage (INSCOV05) are used. As we saw with the SURVEYLOGISTIC procedure, optional CLASS statement requests that they be used as classification variables. The MODEL statement describes the requested linear model. The SOLUTION option requests the regression coefficient estimates. The CONTRAST statement requests hypothesis tests for linear combinations of the regression parameters (see (25) below for the output generated by this statement.

(24) D_EXP_TEST

Effect	NumDF	DenDF	FValue	ProbF
Model	6	249	97.0779	0
Intercept	1	249	834.929	0
POVCAT05	4	249	13.2345	8.62E-10
INSCOV05	2	249	100.651	0

(25) D_EXP_COEFFICIENT

Parameter	Estimate	StdErr	DenDF	tValue	Probt
Intercept	166.508	14.965	249	11.126	0
POVCAT05 1 POOR/NEGATIVE	-124.285	18.569	249	-6.693	1.44E-10
POVCAT05 2 NEAR POOR	-124.623	27.873	249	-4.471	1.18E-05
POVCAT05 3 LOW INCOME	-126.037	20.286	249	-6.213	2.17E-09
POVCAT05 4 MIDDLE INCOME	-67.282	15.272	249	-4.406	1.57E-05
POVCAT05 5 HIGH INCOME	0.000	0.000	249	.	.
INSCOV05 1 ANY PRIVATE	177.040	13.079	249	13.536	0
INSCOV05 2 PUBLIC ONLY	83.982	12.444	249	6.749	1.04E-10
INSCOV05 3 UNINSURED	0.000	0.000	249	.	.

(26) CONTRAST Statement Output

ContrastLabel	NumDF	DenDF	FValue	ProbF
Test low income versus middle income	1	249	11.8716	0.000669

Summary

The SAS survey procedures are an important addition to the SAS statistical PROCS. In addition to providing for variance estimation which incorporates the properties of complex surveys, they have the added benefit of allowing convenient output as SAS data sets.

As the paper by Mukhopadhyay *et al* shows, enhancements for SAS 9.2 will only add to the usefulness of these procedures for analysts working with data from complex surveys.

References

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Appendix

PROC SURVEYMEANS Output for the Program Code in Example (1)

```
                                    TheSURVEYMEANS Procedure

                                           Data Summary

                       Number of Strata                                 203
                       Number of Clusters                               452
                       Number of Observations                         33961
                       Number of Observations Used                    32320
                       Number of Obs with Nonpositive Weights          1641
                       Sum of Weights                             296185002


                                       Stratum Information

             VARIANCE
           ESTIMATION
Stratum       STRATUM
 Index         - 2005       N Obs    Variable    Label                              N    Clusters
-------------------------------------------------------------------------------------------------
   1                1         127    TOTEXP05    TOTAL HEALTH CARE EXP 05         122           3
   2                2         118    TOTEXP05    TOTAL HEALTH CARE EXP 05         112           2
   3                3         110    TOTEXP05    TOTAL HEALTH CARE EXP 05         104           2
   4                4         183    TOTEXP05    TOTAL HEALTH CARE EXP 05         172           3
   5                5         434    TOTEXP05    TOTAL HEALTH CARE EXP 05         414           2
   6                6         198    TOTEXP05    TOTAL HEALTH CARE EXP 05         187           2
   7                7         123    TOTEXP05    TOTAL HEALTH CARE EXP 05         123           2
   8                8         175    TOTEXP05    TOTAL HEALTH CARE EXP 05         166           2
   9                9         106    TOTEXP05    TOTAL HEALTH CARE EXP 05         104           2
  10               10          87    TOTEXP05    TOTAL HEALTH CARE EXP 05          84           3
  11               11         178    TOTEXP05    TOTAL HEALTH CARE EXP 05         169           2
  12               12         212    TOTEXP05    TOTAL HEALTH CARE EXP 05         196           2
  13               13         133    TOTEXP05    TOTAL HEALTH CARE EXP 05         123           2
  14               14         332    TOTEXP05    TOTAL HEALTH CARE EXP 05         309           2
  15               15         111    TOTEXP05    TOTAL HEALTH CARE EXP 05         110           2
  16               16          88    TOTEXP05    TOTAL HEALTH CARE EXP 05          85           2
  17               17         210    TOTEXP05    TOTAL HEALTH CARE EXP 05         196           3
  18               18         107    TOTEXP05    TOTAL HEALTH CARE EXP 05         107           2
  19               19         163    TOTEXP05    TOTAL HEALTH CARE EXP 05         160           2
  20               20         182    TOTEXP05    TOTAL HEALTH CARE EXP 05         173           3
  21               21          81    TOTEXP05    TOTAL HEALTH CARE EXP 05          77           3
  22               22         100    TOTEXP05    TOTAL HEALTH CARE EXP 05          94           3
  23               23         196    TOTEXP05    TOTAL HEALTH CARE EXP 05         189           2
  24               24          71    TOTEXP05    TOTAL HEALTH CARE EXP 05          70           2
  25               25         222    TOTEXP05    TOTAL HEALTH CARE EXP 05         213           2
  26               26         243    TOTEXP05    TOTAL HEALTH CARE EXP 05         231           3
  27               27         103    TOTEXP05    TOTAL HEALTH CARE EXP 05         100           3
  28               28         116    TOTEXP05    TOTAL HEALTH CARE EXP 05         112           2
  29               29         105    TOTEXP05    TOTAL HEALTH CARE EXP 05          99           2
  30               30         204    TOTEXP05    TOTAL HEALTH CARE EXP 05         193           2
  31               31         141    TOTEXP05    TOTAL HEALTH CARE EXP 05         137           2
  32               32         165    TOTEXP05    TOTAL HEALTH CARE EXP 05         157           2
  33               33         236    TOTEXP05    TOTAL HEALTH CARE EXP 05         228           2
  34               34         201    TOTEXP05    TOTAL HEALTH CARE EXP 05         193           2
  35               35         161    TOTEXP05    TOTAL HEALTH CARE EXP 05         151           2
  36               36         156    TOTEXP05    TOTAL HEALTH CARE EXP 05         150           2
  37               37          87    TOTEXP05    TOTAL HEALTH CARE EXP 05          84           3
  38               38          83    TOTEXP05    TOTAL HEALTH CARE EXP 05          82           2
  39               39         112    TOTEXP05    TOTAL HEALTH CARE EXP 05          98           3
  40               40          91    TOTEXP05    TOTAL HEALTH CARE EXP 05          84           2
  41               41         203    TOTEXP05    TOTAL HEALTH CARE EXP 05         185           2
  42               42         129    TOTEXP05    TOTAL HEALTH CARE EXP 05         118           3
  43               43         184    TOTEXP05    TOTAL HEALTH CARE EXP 05         174           2
  44               44         162    TOTEXP05    TOTAL HEALTH CARE EXP 05         158           2
  45               45         208    TOTEXP05    TOTAL HEALTH CARE EXP 05         198           3
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46               46         606    TOTEXP05    TOTAL HEALTH CARE EXP 05          575           2
47               47          37    TOTEXP05    TOTAL HEALTH CARE EXP 05           34           2
48               48         109    TOTEXP05    TOTAL HEALTH CARE EXP 05          102           2
49               49         196    TOTEXP05    TOTAL HEALTH CARE EXP 05          183           2
50               50         106    TOTEXP05    TOTAL HEALTH CARE EXP 05          101           2
51               51         171    TOTEXP05    TOTAL HEALTH CARE EXP 05          165           2
52               52         249    TOTEXP05    TOTAL HEALTH CARE EXP 05          238           2
53               53          62    TOTEXP05    TOTAL HEALTH CARE EXP 05           58           2
54               54          64    TOTEXP05    TOTAL HEALTH CARE EXP 05           61           3
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56               56         115    TOTEXP05    TOTAL HEALTH CARE EXP 05          112           2
57               57         115    TOTEXP05    TOTAL HEALTH CARE EXP 05          106           2
58               58         116    TOTEXP05    TOTAL HEALTH CARE EXP 05          111           3
59               59         202    TOTEXP05    TOTAL HEALTH CARE EXP 05          186           2
60               60         103    TOTEXP05    TOTAL HEALTH CARE EXP 05          102           2
61               61         108    TOTEXP05    TOTAL HEALTH CARE EXP 05           97           2
62               62         345    TOTEXP05    TOTAL HEALTH CARE EXP 05          323           2
63               63         212    TOTEXP05    TOTAL HEALTH CARE EXP 05          208           2
64               64         159    TOTEXP05    TOTAL HEALTH CARE EXP 05          149           2
65               65         152    TOTEXP05    TOTAL HEALTH CARE EXP 05          149           2
66               66          96    TOTEXP05    TOTAL HEALTH CARE EXP 05           94           2
67               67         103    TOTEXP05    TOTAL HEALTH CARE EXP 05           97           2
68               68         150    TOTEXP05    TOTAL HEALTH CARE EXP 05          145           2
69               69         181    TOTEXP05    TOTAL HEALTH CARE EXP 05          175           3
70               70         117    TOTEXP05    TOTAL HEALTH CARE EXP 05          110           2
71               71         152    TOTEXP05    TOTAL HEALTH CARE EXP 05          144           2
72               72         147    TOTEXP05    TOTAL HEALTH CARE EXP 05          138           3
73               73         507    TOTEXP05    TOTAL HEALTH CARE EXP 05          478           2
74               74          84    TOTEXP05    TOTAL HEALTH CARE EXP 05           82           2
75               75         139    TOTEXP05    TOTAL HEALTH CARE EXP 05          128           2
76               76         154    TOTEXP05    TOTAL HEALTH CARE EXP 05          131           2
77               77         183    TOTEXP05    TOTAL HEALTH CARE EXP 05          178           2
78               78         157    TOTEXP05    TOTAL HEALTH CARE EXP 05          151           2
79               79          99    TOTEXP05    TOTAL HEALTH CARE EXP 05           92           2
80               80         446    TOTEXP05    TOTAL HEALTH CARE EXP 05          429           2
81               81         149    TOTEXP05    TOTAL HEALTH CARE EXP 05          147           2
82               82         197    TOTEXP05    TOTAL HEALTH CARE EXP 05          188           3
83               83         148    TOTEXP05    TOTAL HEALTH CARE EXP 05          140           2
84               84         130    TOTEXP05    TOTAL HEALTH CARE EXP 05          122           2
85               85         216    TOTEXP05    TOTAL HEALTH CARE EXP 05          205           3
86               86         126    TOTEXP05    TOTAL HEALTH CARE EXP 05          123           3
87               87         152    TOTEXP05    TOTAL HEALTH CARE EXP 05          148           2
88               88         119    TOTEXP05    TOTAL HEALTH CARE EXP 05          116           2
89               89          99    TOTEXP05    TOTAL HEALTH CARE EXP 05           98           2
90               90         139    TOTEXP05    TOTAL HEALTH CARE EXP 05          134           2
91               91         256    TOTEXP05    TOTAL HEALTH CARE EXP 05          248           3
92               92         139    TOTEXP05    TOTAL HEALTH CARE EXP 05          133           2
93               93         130    TOTEXP05    TOTAL HEALTH CARE EXP 05          129           2
94               94         136    TOTEXP05    TOTAL HEALTH CARE EXP 05          128           2
95               95         633    TOTEXP05    TOTAL HEALTH CARE EXP 05          602           2
96               96         137    TOTEXP05    TOTAL HEALTH CARE EXP 05          135           2
97               97         126    TOTEXP05    TOTAL HEALTH CARE EXP 05          125           2
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100             100         123    TOTEXP05    TOTAL HEALTH CARE EXP 05          114           3
101             101         154    TOTEXP05    TOTAL HEALTH CARE EXP 05          147           2
102             102         175    TOTEXP05    TOTAL HEALTH CARE EXP 05          171           2
103             103          66    TOTEXP05    TOTAL HEALTH CARE EXP 05           59           2
104             104         178    TOTEXP05    TOTAL HEALTH CARE EXP 05          163           2
105             105          76    TOTEXP05    TOTAL HEALTH CARE EXP 05           71           2
106             106          84    TOTEXP05    TOTAL HEALTH CARE EXP 05           79           2
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109             109          97    TOTEXP05    TOTAL HEALTH CARE EXP 05           95           3
110             110         132    TOTEXP05    TOTAL HEALTH CARE EXP 05          130           2
111             111         139    TOTEXP05    TOTAL HEALTH CARE EXP 05          132           2
112             112         100    TOTEXP05    TOTAL HEALTH CARE EXP 05          100           2
113             113         225    TOTEXP05    TOTAL HEALTH CARE EXP 05          209           2
114             114         227    TOTEXP05    TOTAL HEALTH CARE EXP 05          209           2
115             115         145    TOTEXP05    TOTAL HEALTH CARE EXP 05          137           2
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116             116         198    TOTEXP05    TOTAL HEALTH CARE EXP 05         184           3
117             117         182    TOTEXP05    TOTAL HEALTH CARE EXP 05         170           2
118             118         195    TOTEXP05    TOTAL HEALTH CARE EXP 05         185           2
119             119         123    TOTEXP05    TOTAL HEALTH CARE EXP 05         115           2
120             120         113    TOTEXP05    TOTAL HEALTH CARE EXP 05         105           2
121             121         150    TOTEXP05    TOTAL HEALTH CARE EXP 05         140           2
122             122         146    TOTEXP05    TOTAL HEALTH CARE EXP 05         142           3
123             123         143    TOTEXP05    TOTAL HEALTH CARE EXP 05         139           2
124             124         111    TOTEXP05    TOTAL HEALTH CARE EXP 05         106           2
125             125         121    TOTEXP05    TOTAL HEALTH CARE EXP 05         114           2
126             126         174    TOTEXP05    TOTAL HEALTH CARE EXP 05         154           2
127             127         135    TOTEXP05    TOTAL HEALTH CARE EXP 05         128           3
128             128         182    TOTEXP05    TOTAL HEALTH CARE EXP 05         176           2
129             129         120    TOTEXP05    TOTAL HEALTH CARE EXP 05         110           2
130             130          90    TOTEXP05    TOTAL HEALTH CARE EXP 05          87           2
131             131         147    TOTEXP05    TOTAL HEALTH CARE EXP 05         140           2
132             132          68    TOTEXP05    TOTAL HEALTH CARE EXP 05          67           2
133             133         140    TOTEXP05    TOTAL HEALTH CARE EXP 05         123           3
134             134         100    TOTEXP05    TOTAL HEALTH CARE EXP 05          99           3
135             135         380    TOTEXP05    TOTAL HEALTH CARE EXP 05         363           2
136             136         198    TOTEXP05    TOTAL HEALTH CARE EXP 05         193           2
137             137         168    TOTEXP05    TOTAL HEALTH CARE EXP 05         165           2
138             138          72    TOTEXP05    TOTAL HEALTH CARE EXP 05          63           3
139             139         116    TOTEXP05    TOTAL HEALTH CARE EXP 05         112           2
140             140         422    TOTEXP05    TOTAL HEALTH CARE EXP 05         408           3
141             141         182    TOTEXP05    TOTAL HEALTH CARE EXP 05         172           3
142             142          75    TOTEXP05    TOTAL HEALTH CARE EXP 05          73           2
143             143         209    TOTEXP05    TOTAL HEALTH CARE EXP 05         193           2
144             144          97    TOTEXP05    TOTAL HEALTH CARE EXP 05          93           2
145             145         218    TOTEXP05    TOTAL HEALTH CARE EXP 05         200           2
146             146         177    TOTEXP05    TOTAL HEALTH CARE EXP 05         170           2
147             147         199    TOTEXP05    TOTAL HEALTH CARE EXP 05         193           2
148             148          97    TOTEXP05    TOTAL HEALTH CARE EXP 05          91           2
149             149         142    TOTEXP05    TOTAL HEALTH CARE EXP 05         130           2
150             150         176    TOTEXP05    TOTAL HEALTH CARE EXP 05         164           2
151             151         514    TOTEXP05    TOTAL HEALTH CARE EXP 05         490           2
152             152         133    TOTEXP05    TOTAL HEALTH CARE EXP 05         127           2
153             153         138    TOTEXP05    TOTAL HEALTH CARE EXP 05         137           2
154             154         127    TOTEXP05    TOTAL HEALTH CARE EXP 05         121           3
155             155         224    TOTEXP05    TOTAL HEALTH CARE EXP 05         217           3
156             156         119    TOTEXP05    TOTAL HEALTH CARE EXP 05         115           2
157             157         192    TOTEXP05    TOTAL HEALTH CARE EXP 05         179           2
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160             160         198    TOTEXP05    TOTAL HEALTH CARE EXP 05         190           3
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162             162         211    TOTEXP05    TOTAL HEALTH CARE EXP 05         207           2
163             163         116    TOTEXP05    TOTAL HEALTH CARE EXP 05         113           3
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166             166          58    TOTEXP05    TOTAL HEALTH CARE EXP 05          53           2
167             167         248    TOTEXP05    TOTAL HEALTH CARE EXP 05         229           2
168             168         146    TOTEXP05    TOTAL HEALTH CARE EXP 05         145           2
169             169         178    TOTEXP05    TOTAL HEALTH CARE EXP 05         166           2
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172             172         325    TOTEXP05    TOTAL HEALTH CARE EXP 05         301           2
173             173          88    TOTEXP05    TOTAL HEALTH CARE EXP 05          83           3
174             174         178    TOTEXP05    TOTAL HEALTH CARE EXP 05         176           2
175             175         268    TOTEXP05    TOTAL HEALTH CARE EXP 05         262           2
176             176         143    TOTEXP05    TOTAL HEALTH CARE EXP 05         134           2
177             177         725    TOTEXP05    TOTAL HEALTH CARE EXP 05         677           2
178             178         172    TOTEXP05    TOTAL HEALTH CARE EXP 05         161           2
179             179         281    TOTEXP05    TOTAL HEALTH CARE EXP 05         267           2
180             180         280    TOTEXP05    TOTAL HEALTH CARE EXP 05         257           3
181             181          72    TOTEXP05    TOTAL HEALTH CARE EXP 05          70           2
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183             183         180    TOTEXP05    TOTAL HEALTH CARE EXP 05         170           2
184             184         187    TOTEXP05    TOTAL HEALTH CARE EXP 05         182           2
185             185         160    TOTEXP05    TOTAL HEALTH CARE EXP 05         157           2
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  186             186         126    TOTEXP05    TOTAL HEALTH CARE EXP 05         124           3
  187             187         199    TOTEXP05    TOTAL HEALTH CARE EXP 05         197           3
  188             188         134    TOTEXP05    TOTAL HEALTH CARE EXP 05         133           2
  189             189         208    TOTEXP05    TOTAL HEALTH CARE EXP 05         194           2
  190             190         164    TOTEXP05    TOTAL HEALTH CARE EXP 05         161           3
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  192             192         202    TOTEXP05    TOTAL HEALTH CARE EXP 05         195           2
  193             193         115    TOTEXP05    TOTAL HEALTH CARE EXP 05         103           2
  194             194          99    TOTEXP05    TOTAL HEALTH CARE EXP 05          90           2
  195             195         110    TOTEXP05    TOTAL HEALTH CARE EXP 05         107           3
  196             196         185    TOTEXP05    TOTAL HEALTH CARE EXP 05         179           3
  197             197         224    TOTEXP05    TOTAL HEALTH CARE EXP 05         216           2
  198             198          60    TOTEXP05    TOTAL HEALTH CARE EXP 05          58           2
  199             199         175    TOTEXP05    TOTAL HEALTH CARE EXP 05         172           2
  200             200         145    TOTEXP05    TOTAL HEALTH CARE EXP 05         140           2
  201             201          80    TOTEXP05    TOTAL HEALTH CARE EXP 05          80           2
  202             202         115    TOTEXP05    TOTAL HEALTH CARE EXP 05         112           3
  203             203         147    TOTEXP05    TOTAL HEALTH CARE EXP 05         142           2
-------------------------------------------------------------------------------------------------


                                            Statistics

                                                                          Std Error
               Variable    Label                               Mean         of Mean
               --------------------------------------------------------------------
               TOTEXP05    TOTAL HEALTH CARE EXP 05     3456.500008       90.433709
               --------------------------------------------------------------------
```