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An Easy-to-Use SAS® Table Formatting Macro: Stand-Alone, Flexible, and Quick

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ABSTRACT

A reporting macro was created with the following requirements: functionality similar to PROC TABULATE, much better than PROC TABULATE for controlling output layout, ease of incorporating non-PROC TABULATE statistics, and overall ease of use. The table definition mimics the final output and includes text, macro variables, macro calls, and special characters (cell and row separators, decimal tab, line feed, repeated column characters). The sub-macros %c(*cname*) and %e define a categorical variable *cname* and its scope within the table definition. To define a continuous variable, a pair of sub-macros, %v(*vname*) and %e, are used. The variables can be nested in a similar way to PROC TABULATE. If within the table definition there are macro variables that have names equal to the PROC TABULATE statistical keywords, the macro will call PROC TABULATE to resolve them. To build the call, the macro uses the information about the location of the particular statistical keyword within the table definition in relation to the scope of the *cname/vname* variables. After resolution of the table specific macro variables, the table definition is executed by the macro processor; that is, the macro variables are substituted, and the user macros called. During the execution the characters between the %c(*cname*) and %e will be processed for each category of *cname*, and for each iteration the category name will be available as &*cname*. The resulting string of characters is divided into rows and cells and constitutes the data set that reflects the initial table definition. That dataset is the input for the required final ODS processing: RTF, PDF, HTML, etc. Utilizing this macro to its full potential enables the user to produce diverse professional looking reports with varied and complex statistics with relative ease.

INTRODUCTION

Formatting tables in SAS for clinical trial data presents a challenge especially when maximum flexibility of combining summary statistics, confidence intervals, and p-values is desired. PROC TABULATE provides a broad range of summary statistics but is not that flexible with regard to table layout or incorporating other externally generated information. Other procedures require very detailed data manipulation before the desired table can be produced. One solution to this problem is to construct a table-submitter macro where the macro call actually mimics the table layout desired.

TEST DATA

The following data set will be used to create examples:

```
data test;
  retain seed 117;
  do i=1 to 1000;
    if ranuni(seed)<.5 then group='Group A'; else group='Group B';
    if ranuni(seed)<.5 then gender='M'; else gender='F';
    if ranuni(seed)<.5 then origin='Caucasian'; else origin='Hispanic ';
    if ranuni(seed)>.005 then age=60+5*normal(seed); else age=.;
    output;
  end;
run;
```

INTRODUCTORY EXAMPLE

The paragraph below shows a call of the main macro: %table and the RTF output produced by the call:

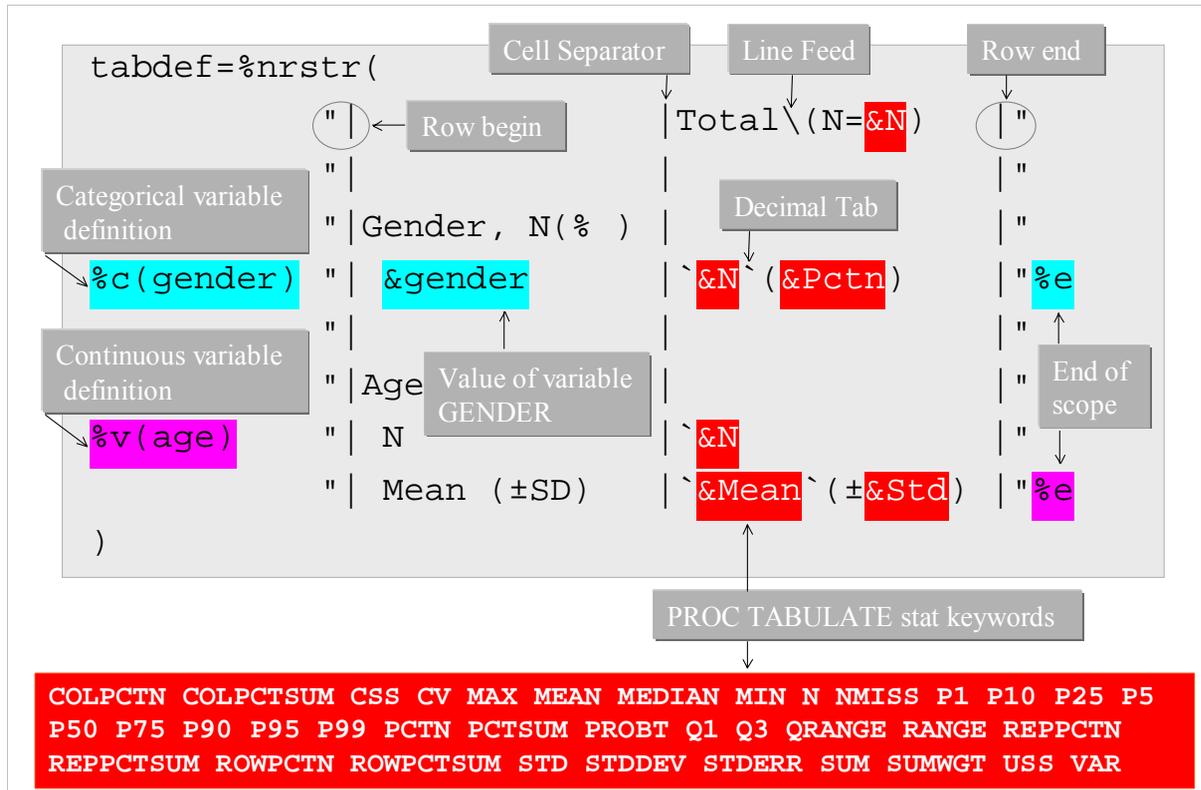
```
%table(data=test, rtf=Y, title="Example",
tabdef=%nrstr(
  " | | Total \ (N=&N) | "
  " | | | | "
  " | Gender, N(% ) | | "
  %c(gender) " | &gender | `&N` (&Pctn) | "%e
  " | | | | "
  " | Age, years | | | "
  %v(age) " | N | `&N | "
  " | Mean (±SD) | `&Mean` (±&Std) | "%e
));
```

Note that parameter *tabdef* actually mimics the layout of the final output.

Example	
	Total (N=1000)
Gender, N(%)	
F	492 (49.20)
M	508 (50.80)
Age, years	
N	993
Mean (±SD)	59.94 (±5.026)

BASIC ELEMENTS OF TABLE DEFINITION

Let's look at the above call of `%table` and identify some elements of the table definition:



PROC TABULATE STATISTICAL KEYWORDS

`%table` macro will analyze the table definition and will call PROC TABULATE to obtain the information for resolving the macro variables which refer to the PROC TABULATE statistical keywords.

C AND V SUB-MACROS

The `%c(cname)` declares a categorical variable `cname`. The text between `%c` and its respective `%e` will be processed for each category of `cname`, and the category name will be available within each iteration as `&cname` (instead of `&cname` the `&c` can be used; `&c` refers to the most recent declaration). E.g. for our test data the `%c(gender)"|&gender|" %e` code will result in `"|F|""|M|"` text.

For the call to PROC TABULATE the `cname` will be declared within the CLASS statement.

The `%v(vname)` declares a continuous variable `vname`.

For the call to PROC TABULATE the `vname` will be declared within the VAR statement.

INTERNAL NAMING CONVENTIONS

The `%table` macro changes all the table definition references to PROC TABULATE statistical keywords to a form `scope_stat` or `scope_vname_stat`, where `stat` is the statistical keyword, and the `scope` for `%c(cname1)...`

`%c(cname2)... &stat ... %e... %e` is of a form `Ci1Lj1Ci2Lj2...`, where `i1` is a position number of `cname1` within the CLASS statement, `j1` is the category (level) number of the `cname1`, etc.

E.g. for the above example the `gender &N` will be referenced as `&C1L1_N` for `F`, and `&C1L2_N` for `M` gender; and the `age &N` will be referenced as `&_age_N`.

DECIMAL TAB

The character ``` is treated by `%table` as a decimal tab that allows numbers to be lined-up. The ``` will be replaced by the definition of the decimal tab (i.e. the distance from the left border of the cell) and the tab itself.

E.g. for the RTF destination the first (within a cell) ``` will produce the `!tqdec!x!650!tab`, the second the `!tqdec!x!1300!tab` code, and so on.

OTHER ELEMENTS OF TABLE DEFINITION

REPEATED COLUMN CHARACTERS

Most tables of clinical trial data include comparisons between groups (e.g. treatments). With the `%table` macro, each group category column is repeated using the same format/layout and the category specific information.

The `%table` macro provides a parameter `coldef` which allows easy definition of such columns:

```
%table(data=test, rtf=Y, coldef=%nrstr(%c(group, char1=[, char2=])),
tabdef=%nrstr(
  " | &group\ (N=&N) ] | "
  " | Gender, N(% ) ] | "
  %c(gender) " | &c [ | `&N` (&ColPctn) ] | "%e));
```

Each occurrence of `[` and `]` within the `&tabdef` will be replaced by `%c(group)` and `%e` calls, respectively.

So the above table definition is equivalent to:

```
tabdef=%nrstr(
  " | %c(group) | &group\ (N=&N) %e | "
  " | Gender, N(% ) %c(group) | %e | "
  %c(gender) " | &c %c(group) | `&N` (&ColPctn) %e | "%e)
```

And the result is as follows:

	Group A (N=494)		Group B (N=506)	
Gender, N(%)				
F	257	(52.02)	235	(46.44)
M	237	(47.98)	271	(53.56)

The `[` and `]` are the defaults for `%table`.

SUBSET

It often happens that we want to show only selected categories in a table. The second positional parameter of the `%c` submacro will be treated by the macro processor as a logical condition. So the actual `%c` syntax is `%c(cname, lcondition)`. The `lcondition` will be evaluated for each category of variable `cname`, and the text between `%c` and `%e` brackets will be processed only when the condition is true.

So the following code:

```
%table(data=test, rtf=Y, coldef=%nrstr(%c(group)), tabdef=%nrstr(
  " | [ | &c\ (N=&N) ] | "
  " | [ | ] | "
  %c(gender, &c=F) " | Female Gender, N(% ) [ | `&N` (&ColPctn) ] | "%e));
```

Will produce the following output:

	Group A (N=494)		Group B (N=506)	
Female Gender, N(%)	257	(52.02)	235	(46.44)

The `%c` which defines the repeated columns can use the selection condition, too. I.e. the

```
... coldef=%nrstr(%c(group, &c=Group A))...
```

will not produce the *Group B* column.

DENOMINATOR

The denominators for calculating percentages can be defined in the same way as for PROC TABULATE:

```
%table(data=test, rtf=Y, coldef=%nrstr(%c(group)), tabdef=%nrstr(
  " | [ | &c\ (N=&N) ] | "
  %c(origin) " | [ | ] | "
  " | &c Origin [ | N=`&N` ] | "
  " | Gender, N(% ) [ | ] | "
  %c(gender) " | &c [ | `&N` (&Pctn<gender>) ] | "%e%e));
```

As the result each *origin* is treated as 100% for *gender* percentages:

	Group A (N=494)	Group B (N=506)
Caucasian Origin	N= 261	N= 237
Gender, N(%)		
F	133 (50.96)	98 (41.35)
M	128 (49.04)	139 (58.65)
Hispanic Origin	N= 233	N= 269
Gender, N(%)		
F	124 (53.22)	137 (50.93)
M	109 (46.78)	132 (49.07)

F SUB-MACRO

The %f submacro provides a way of including external (i.e. not from PROC TABULATE) information in the table. The syntax is %f(*dname,vname,vformat*). When called during processing of the table definition, %f opens the *dname* data set and returns the text which is the result of reading *vname* variable using the given format *vformat*.

When %f call occurs within a scope of %c(*cname1*), %c(*cname2*),... calls, then it opens *dname* with a *where=(cname1=&cname1 and cname2=&cname2 ...)* condition. When >1 record is available then the reads are separated by Line Feeds.

The following PROC FREQ call will produce a p-value for each *origin* category:

```
proc freq data=test noprint;
  table origin*gender*group/fisher;
  output out=xf fisher;
run;
```

The %f is nested within the %c(*origin*) and its %e brackets, so %f will be called twice: once for *Caucasian*, once for *Hispanic* origin; the first call will open *xf(where=(origin="Caucasian"))*, the second: *xf(where=(origin="Hispanic"))*:

```
%table(data=test, rtf=Y, coldef=%nrstr(%c(group)), tabdef=%nrstr(
  %c(origin) " | [ &c\ (N=&N) ] | p-Value* | "
  " | [ | ] | | "
  " | &c Origin [ N= `&N ] | | "
  " | Gender, N(%) [ ] | ` %f(xf, xp2_fish, pvalue6.) | "
  %c(gender) " | &c [ `&N` (&Pctn<gender>) ] | | "%e%e
  " | [ ] | | "
), footnote="* - Fisher's exact test");
```

And the result:

	Group A (N=494)	Group B (N=506)	p-Value*
Caucasian Origin	N= 261	N= 237	
Gender, N(%)			0.0384
F	133 (50.96)	98 (41.35)	
M	128 (49.04)	139 (58.65)	
Hispanic Origin	N= 233	N= 269	
Gender, N(%)			0.6544
F	124 (53.22)	137 (50.93)	
M	109 (46.78)	132 (49.07)	

* - Fisher's exact test

U SUB-MACRO

The `%table` macro makes use of the `%unquote` twice when the table definition `tabdef` is processed. This fact makes it more complicated to place within the table definition a 'proper' call to a user-written macro that refers to the table specific macro variables (like `&cname`, `&N`, etc.). One way is to use `%nrstr` calls, which will delay the execution of the user macro. A second way is to use the `%u` macro, since the `%table` will synchronize the execution of calls to `%u` with the moment when all the table specific macro variables are resolved.

As an example let's assume that we want to calculate the difference in age between group A and B:

```
proc ttest data=test;
  class group;
  var age;
  ods output statistics=s(where=(class='Diff (1-2)'));
run;
data _null_;
  set s;
  call symput('diff', '' || put(mean,best5.) || ' '(±' || put(stderr,best5.) || ')');
run;
```

... and to show it in column *Group A*:

```
%macro u(group);
%if %unquote(&group)=Group A %then &diff;
%mend u;
%table(data=test, rtf=Y, coldef=%nrstr(%c(group)), tabdef=%nrstr(
  " |                               [ |&group\ (N=&N)                ] | "
  " |Age, years                    [ |                               ] | "
%v(age)  " | N                      [ | `&N                          ] | "
  " | Mean (±SE)                   [ | `&Mean` (±&StdErr)         ] | "%e
  " | Mean Diff. (±SE) [ | %u(&group)                ] | "));
```

And the result will be:

	Group A (N=494)	Group B (N=506)
Age, years		
N	490	503
Mean (±SE)	59.71 (±0.227)	60.16 (±0.224)
Mean Diff. (±SE)	-0.45 (±0.319)	

NUMBER OF DECIMAL PLACES

The number of decimal places shown in a table for a PROC TABULATE specific statistic is controlled as follows:

- 2 decimal places for percentages
- for a statistic related to a continuous variable
 - o `best5.` format if the variable is not formatted
 - o number of decimal places of the formatted variable increased by `&dstat`, where `stat` is the name of the PROC TABULATE statistical keyword. E.g. For `mean`, the default `&dmean` is 1, for `stderr` the `&dstderr` is 2. The defaults can be changed within the `%table` call: e.g. `%table(...,dmean=2,...)`.

In the below example the format of the variable `age` is `5.`, i.e. with 0 decimal places:

```
%table(data=test, rtf=Y, coldef=%nrstr(%c(group)), format=age 5.,
tabdef=%nrstr(
  " |                               [ |&group\ (N=&N)                ] | "
  " |Age, years                    [ |                               ] | "
%v(age)  " | N                      [ | `&N                          ] | "
  " | Mean (±SE)                   [ | `&Mean` (±&StdErr)         ] | "%e));
```

So the `&Mean` will be displayed with $0+1=1$, and the `&StdErr` with $0+2=2$ decimals:

	Group A (N=494)	Group B (N=506)
Age, years		
N	490	503
Mean (±SE)	59.7 (±0.23)	60.2 (±0.22)

DATA SET WITH TABLE CONTENT

The resulting text is divided into rows/cells and a data set is created:

	_col1	Total\N=1000)
1		
2	Gender, N(%)	
3	F	492 (49.20)
4	M	508 (50.80)
5		
6	Age, years	
7	N	993
8	Mean (\pm SD)	59.94 (\pm 5.026)

DATA SET WITH FORMATTED TABLE CONTENT

Up to this point the processing is independent from the destination format.

The `%table rtf=Y` parameter will force RTF formatting, which will create another data set:

	_col1	Total\N=1000)
1	^R"\keepn"	
2	Gender, N(%)^R"\keepn"	
3	F^R"\li200 " ^R"\keepn"	^R"\tab " ^R""492^R"\tab " ^R""(49.20)^R"\tqdec\tx650 " ^R"\tqdec\tx1300 "
4	M^R"\li200 "	^R"\tab " ^R""508^R"\tab " ^R""(50.80)^R"\tqdec\tx650 " ^R"\tqdec\tx1300 "
5	^R"\keepn"	
6	Age, years^R"\keepn"	
7	N^R"\li200 " ^R"\keepn"	^R"\tab " ^R""993^R"\tqdec\tx650 " ^R"\tqdec\tx1300 "
8	Mean (\pm SD)^R"\li200 " ^R"\keepn"	^S={cellwidth=3.3177083333cm} ^R"\tab " ^R""59.94^R"\tab " ^R""(\pm 5.026)^R"\tqdec\tx650 " ^R"\tqdec\tx1300 "

TEMPLATES AND FILE PRINT ODS=

The formatted data set will be printed using FILE ODS=(TEMPLATE=...) statement:

Example	
	Total (N=1000)
Gender, N(%)	
F	492 (49.20)
M	508 (50.80)
Age, years	
N	993
Mean (\pm SD)	59.94 (\pm 5.026)

DISCUSSION

The `%table` macro has been used extensively to produce thousands of pages of output summarizing clinical trials. It has proved its usefulness, however some weak points have become apparent. One of them is because the table definition is stored in a macro variable. That means that at each stage of processing the table – which ‘lives’ as a text string – cannot be longer than 32K characters in SAS 8 (64K in SAS 9). This problem has been partially addressed by delaying the resolution of a macro variable if the resolved text is longer than the macro variable name. A second weakness is that the internal names of the table specific macro variables can easily reach the 32 characters limit, for example if there is high degree of nesting (approximately ≥ 4 levels). But generally the `%table` macro works fast and efficiently, and substantially reduces the amount of text produced in the log file.

CONCLUSION

1. The `%table` macro builds similar tables to PROC TABULATE but has much greater flexibility regarding the layout
2. By using macro variables and macro calls within the table definition, the user can incorporate any kind of statistics into the final table
3. Output can be easily redirected to the different destinations (rtf, pdf, html,...)
4. The macro builds the table using only one call of PROC TABULATE (instead of, for example, calling PROC FREQ/UNIVARIATE for each row of the table).

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