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Using Macro in SAS® to Calculate Kappa and 95% CI for Several Pairs of Nurses of Chemical Triage

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ABSTRACT

It is often necessary to assess multi-rater agreement for multiple observation categories in case controlled studies. The Kappa statistic is one of the most common agreement measures for categorical data. The purpose of this paper is to show an approach for using the SAS® 9.4[2] procedures, including Macro language, to estimate Kappa with 95% CI for pairs of nurses that used two different triage systems during a computer simulated chemical mass casualty incident (MCI). This paper used data from the Validating Triage for Chemical Mass Casualty Incidents – A First Step R01 grant to assess the performance of a typical hospital triage system called the Emergency Severity Index (ESI)[14] compared with an Irritant Gas Syndrome Agent Syndrome (IGSA) Triage Algorithm, being developed from this grant, to quickly prioritize the treatment of victims of IGSA incidents. Six different pairs of nurses used ESI triage and seven pairs of nurses used the IGSA Triage prototype to assess 25 patients exposed to an IGSA and 25 patients not exposed.

Of the 13 pairs of nurses in this study two pairs were randomly selected to illustrate the use of Macro language for this paper. If the data was not square for two nurses a square form table for observers using pseudo-observations was created. A weight of 1 for real observations and a weight of .0000000001 for pseudo-observations was assigned. Several Macros were used to reduce programing. In this paper we show only the result of one pair nurses for ESI and IGSA (nurses 5 and 12 for ESI triage and nurses 20 and 23 for IGSA). The results indicated very poor agreement for nurse 5 and 12 (simple kappa=.07 with 95% CI -.04 to .17 and weighted kappa =.20 with 95% CI of .10 to .30). However, the result excellent agreement for nurses 20 and 23 (simple kappa=.79 with 95% CI .68 to .90 and weighted kappa =.89 with 95% CI of .81 to .97).

Keywords: SAS, Kappa, Agreement,

University of South Carolina, College of Nursing.

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INTRODUCTION

It is often necessary to assess multi-rater agreement for multiple observation categories in case controlled studies. The Kappa statistic is one of the most common agreement measures for categorical data[1]. The Kappa statistic calculates the percentage of agreement among two or more raters after removing the percentage of agreement which would occur by chance. The SAS ®[2] PROC FREQ procedure supports application of the Kappa statistic for two raters and several categories. However, the calculation is not straightforward when two raters with more than two categories of data must first be manipulated in a square form table in order to use the SAS ® PROC FREQ procedure. This paper shows how the use of Macro language can reduce the lines of syntax for PROC FREQ procedures when applied to multi-rater agreement that use multiple observation categories.

PURPOSE

The purpose of this paper is to show an approach for using the SAS® 9.4[2] procedures, including Macro language, to estimate Kappa with 95% CI for several pairs of nurses that used two hospital triage systems during a computer simulated chemical mass casualty incident. Of the 13 pairs of nurses who participated in this simulation, we show only the results of one pair nurses for each of the triage systems.

BACKGROUND

Irritant Gas Syndrome Agents (IGSA) and a variety of other products are important manufacturing raw materials and are transported daily through communities by rail, truck and boat.[3-8] Exposure to IGSAs can happen in a variety of settings, including situations which involve deliberate release of these agents, that could kill or injure hundreds or thousands of people. Chemical incidents involving irritant chemicals such as chlorine pose a significant threat to life and require rapid assessment and triage. Emergency responders and hospital personnel use triage to rapidly assess patients and prioritize their care with the goal of saving as many lives as possible. None of the current triage systems evaluated in our previous study were effective in establishing a triage priority for victims exposed to chlorine, an IGSA.[9-13] We are developing a new IGSA Triage Algorithm prototype to more accurately and efficiently triage victims of IGSA incidents.

METHODS

This paper used the medical record data abstractions from the Validating Triage for Chemical Mass Casualty Incidents – A First Step R01 grant, to assess the performance of a typical hospital triage system (ESI) compared with our new IGSA Triage Algorithm prototype to quickly prioritize the treatment of victims of IGSA incidents. ESI prioritizes patients into one of five triage classifications. Our IGSA Triage Algorithm prototype, being evaluated in this study, uses 4 triage classifications.

Data included 147 patients exposed to an IGSA and 152 patients not exposed for this computer simulation. The twenty-six nurses that volunteered for this computer simulation were randomly assigned to either the ESI or the IGSA Triage group. The twenty-six nurses were then randomly assigned to a pair of nurses that would assess the same patients to test agreement between the nurses. Six different pairs of nurses used ESI triage and seven pairs of nurses used the IGSA Triage prototype to assess 25 patients exposed to an IGSA and 25 patients not exposed. Each nurse assessed 50 patients twice for a total of100 observations/nurse. Of the 13 pairs of nurses in this study, only two pair was randomly selected to illustrate the use of Macro language for this paper.

To calculate Kappa for each pair of nurses for ESI and IGSA we could create thirteen different datasets and thirteen PROC FREQ procedures (see example of SAS syntax in appendix). This would very lengthy syntax when we have many pairs of raters. Several Macros used to reduce programing (See example of Macro for ESI in appendix). In this paper we show only the result of one pair nurse (nurse 5 and 12 for ESI triage). However, the SAS syntax showed all pairs for ESI triage. The same syntax used for IGSA triage method.

PROC FREQ, TRANSPOSE, and PRINT were used to estimate Kappa and simple / weighted confidence interval. The study included many pairs of nurses to conduct the experiment. If the data was not square for two raters a square form table for observers using pseudo-observations was created. A weight of 1 for real observations and a weight of .0000000001 for pseudo-observations was assigned. Pseudo-observations ensure responses for every category assigned by any other observers and the small weight does not have any effect on the Kappa statistic. Macro language used to reduce many coding. All data analyses were performed using SAS/STAT® version 9.4[4].

RESULTS

Table 1 shows first 20 observations ESI level selected by nurses 5 and 12. For example nurses 5 and 12 selected the same level (4) for observation 1 (epid=1002) but nurse 5 selected level 4 for epid 1012 whereas nurse 12 selected level 2. Table 2 indicates first 20 observations IGSA level selected by nurses 20 and 23. For example nurses 5 and 12 selected the same level (urgent) for observation 1 (ipid=1003) but nurse 20 selected level monito for ipid 1024 whereas nurse 23 selected level urgent.

Table 1: ESI Level selected by nurse 5 and 12 (first 20 observations).

Obs	epid	Elevel1	Elevel2
1	1002	4	4
2	1012	4	2
3	1018	3	3
4	1019	5	3

Obs	epid	Elevel1	Elevel2
5	1026	3	2
6	1034	4	2
7	1044	3	2
8	1050	5	2
9	1053	3	2
10	1061	3	2
11	1067	3	3
12	1069	3	3
13	1084	4	3
14	1090	4	3
15	1093	5	3
16	1098	4	4
17	1105	3	2
18	1109	4	3
19	1120	5	3
20	1129	3	2

Note: elevel1= nurse 5 and elevel2 = nurse 12

Table 2: IGSA Level selected by nurse 20 and 23 (first 20 observations).

Obs	ipid	elevel1	elevel2
1	1003	urgent	urgent
2	1006	no exposure	no exposure
3	1007	no exposure	no exposure
4	1024	monitor	urgent
5	1032	monitor	monitor
6	1040	urgent	urgent
7	1048	monitor	.
8	1057	no exposure	no exposure
9	1058	monitor	monitor
10	1066	monitor	monitor
11	1073	urgent	urgent
12	1082	monitor	monitor
13	1088	.	monitor
14	1102	monitor	monitor
15	1115	monitor	monitor
16	1122	no exposure	no exposure
17	1126	no exposure	no exposure
18	1127	urgent	urgent

Obs	ipid	elevel1	elevel2
19	1133	no exposure	no exposure
20	1134	monitor	monitor

Note: elevel1= nurse 20 and elevel2 = nurse 23

Table 3: Frequency distribution ESI by nurse 5 and 12

Table of elevel1 by elevel2						
elevel1	**elevel2**					
Frequency Percent Row Pct Col Pct	**1**	**2**	**3**	**4**	**5**	**Total**
1	1 0.99 100.00 50.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 0.99
2	1 0.99 12.50 50.00	4 3.96 50.00 11.11	2 1.98 25.00 4.65	1 0.99 12.50 7.14	0 0.00 0.00 0.00	8 7.92
3	0 0.00 0.00 0.00	20 19.80 64.52 55.56	10 9.90 32.26 23.26	1 0.99 3.23 7.14	0 0.00 0.00 0.00	31 30.69
4	0 0.00 0.00 0.00	6 5.94 23.08 16.67	14 13.86 53.85 32.56	6 5.94 23.08 42.86	0 0.00 0.00 0.00	26 25.74
5	0 0.00 0.00 0.00	6 5.94 17.14 16.67	17 16.83 48.57 39.53	6 5.94 17.14 42.86	6 5.94 17.14 100.00	35 34.65
Total	2 1.98	36 35.64	43 42.57	14 13.86	6 5.94	101 100.00

Note: elevel1= nurse 5 and elevel2 = nurse 12

Table 4: Frequency distribution IGSA by nurse 20 and 23

Table of elevel1 by elevel2					
elevel1	**elevel2**				
Frequency Percent Row Pct Col Pct	**level 1**	**urgent**	**monitor**	**no exposure**	**Total**
level 1	1E-10 0.00 0.00 100.00	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 1.15 100.00 2.44	1 1.15
urgent	0 0.00 0.00 0.00	6 6.90 50.00 66.67	6 6.90 50.00 16.22	0 0.00 0.00 0.00	12 13.79
monitor	0 0.00 0.00 0.00	3 3.45 9.09 33.33	30 34.48 90.91 81.08	0 0.00 0.00 0.00	33 37.93
no exposure	0 0.00 0.00 0.00	0 0.00 0.00 0.00	1 1.15 2.44 2.70	40 45.98 97.56 97.56	41 47.13
Total	1E-10 0.00	9 10.34	37 42.53	41 47.13	87 100.00
Frequency Missing = 4					

Note: elevel1= nurse 20 and elevel2 = nurse 23

Table 3 shows frequency distribution of ESI level selected by nurses 5 and 12. The result we only have one observation for level1 which both nurses selected. However, for level 2, level 3, level 4, and level 5 both nurses selected the same only 50 %, 32.3 %, 23.1%, and 17.1 %; respectively. Table 4 indicates frequency distribution of IGSA level selected by nurses 20 and 23. The result we only have one observation for level1 which only nurse 20 selected as no exposure. The result revealed for level urgent, level monitor and level no exposure both nurses selected the same only 50 %, 90.9 %, and 97.6 %; respectively.

Table 5: Simple and weighted Kappa with 95% CI for ESI nurse 5 and 12.

Simple Kappa Coefficient	
Kappa	0.0662
ASE	0.0529
95% Lower Conf Limit	-0.0374
95% Upper Conf Limit	0.1699

Test of H0: Kappa = 0	
ASE under H0	0.0459
Z	1.4414
One-sided Pr > Z	0.0747
Two-sided Pr > |Z|	0.1495

Weighted Kappa Coefficient	
Weighted Kappa	0.1963
ASE	0.0504
95% Lower Conf Limit	0.0976
95% Upper Conf Limit	0.2950

Test of H0: Weighted Kappa = 0	
ASE under H0	0.0447
Z	4.3925
One-sided Pr > Z	<.0001
Two-sided Pr > |Z|	<.0001

Table 6: Simple and weighted Kappa with 95% CI for IGSA nurse 20 and 23.

Simple Kappa Coefficient	
Kappa	0.7901
ASE	0.0559
95% Lower Conf Limit	0.6806
95% Upper Conf Limit	0.8996

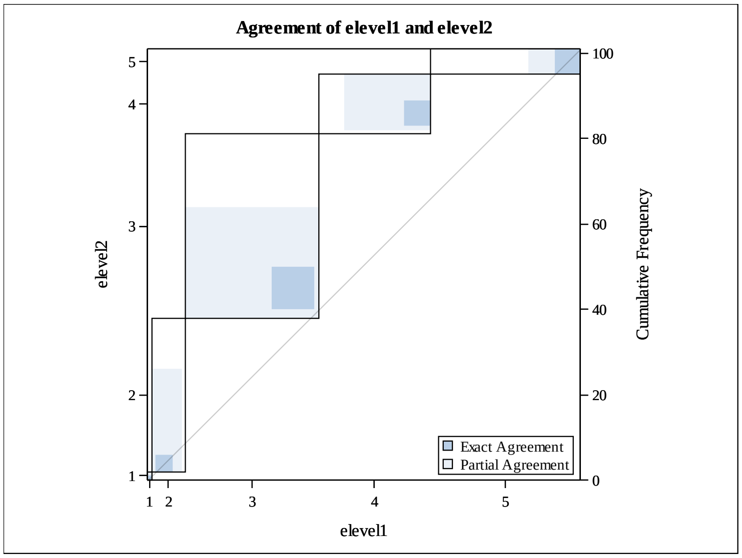
Test of H0: Kappa = 0	
ASE under H0	0.0822
Z	9.6120
One-sided Pr > Z	<.0001
Two-sided Pr > |Z|	<.0001

Weighted Kappa Coefficient	
Weighted Kappa	0.8870
ASE	0.0407
95% Lower Conf Limit	0.8073
95% Upper Conf Limit	0.9667

Test of H0: Weighted Kappa = 0	
ASE under H0	0.0954
Z	9.2991
One-sided Pr > Z	<.0001
Two-sided Pr > |Z|	<.0001

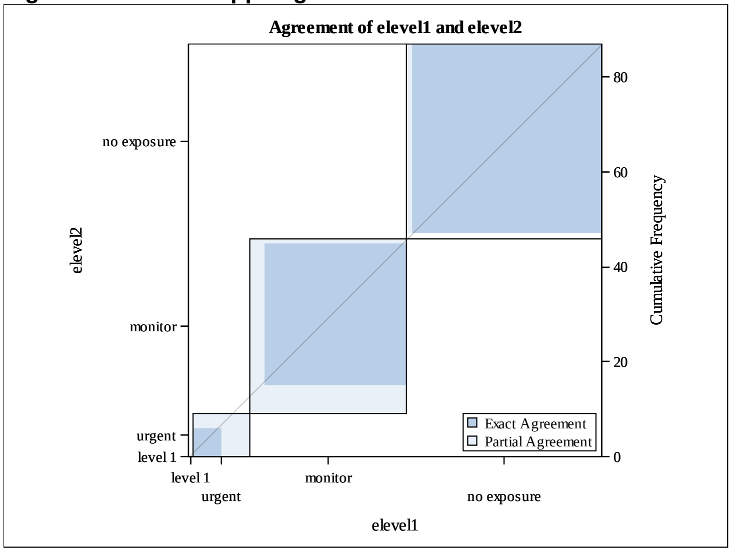
Table 5 indicates the result of Kappa agreement for ESI with nurse 5 and 12. The result indicate very poor agreement for nurse 5 and 12 (simple kappa=.07 with 95% CI -.04 to .17 and weighted kappa =.20 with 95% CI of .10 to .30). Table 6 shows the result of Kappa agreement for IGSA with nurses 20 and 23. The result indicate excellent agreement for nurses 20 and 23 (simple kappa=.79 with 95% CI .68 to .90 and weighted kappa =.89 with 95% CI of .81 to .97).

Figure 1: Plot of Kappa agreement for ESI with nurse 5 and 12.



Note: elevel1= nurse 5 and elevel2 = nurse 12

Figure 2: Plot of Kappa agreement for IGSA with nurse 20 and 23.



Note: elevel1= nurse 20 and elevel2 = nurse 23

Figure 1 indicates the plot of Kappa agreement for ESI with nurses 5 and 12. The result indicates very poor agreement for each level by nurse 5 and 12. Figure 2 shows the plot of Kappa agreement for IGSA with nurses 20 and 23. The result indicates excellent agreement for urgent, monitor, and no exposure by nurses 20 and 23.

CONCLUSION

This paper provides an example of how to use macro to calculate percentage agreement with the Kappa statistic with 95% CI using SAS ® PROC FREQ, MEANS, and PRINT when we have several pairs of raters. This paper expands the current functionality of the SAS ® PROC FREQ procedure to support application of the Kappa statistic using macro to reduce length syntax in program.

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Appendix

SAS Syntax

```
**** Example of Kappa for Nurs 5 and 12 pairs for ESI    ***;
data five ;
set two;
if enid = 5 or enid=12;  run;
proc sort data=five ;     by epid;
**** here to create several column for each record using transpose procedure   for each pair of nurse ***;
proc freq data=five noprint;
   tables Epid / out=eF512 ; run;
proc sort data = ef512;   by epid;
data en512;
  merge five ef512;
  by epid;   run;
proc sort data=en512;
    by epid; run;
data en512b;
   set en512;
if count=2;run;
proc sort data=en512b;
    by epid; run;
PROC TRANSPOSE DATA=en512b
OUT=en512w (DROP=_NAME_ _LABEL_)
```

```
PREFIX=elevel;
BY epid;
VAR esi_calclevel;RUN;
proc sort data=en512w; by  epid; run;
data pseudo ;
   infile datalines ;
   wt = .0000000001;
   input elevel1 elevel2 ;
   datalines;
   1 1
   2 2
   3 3
   4 4
   5 5
   ;  run;
 data all512 ;
   set en512w pseudo ; run;
ods rtf;ods listing close;
proc print data=all512;
var  epid elevel1 elevel2  ;
title ' printing data / nurse 5 and 12 ' ;run;
proc freq data=all512;
          tables elevel1*elevel2 / agree ;
                                test AGREE;
title ' frequency tables / Kappa Agreement/ nurses 5 and 12'; run;
ods rtf close; ods listing; quit; run;

**** create macro to run for different pairs of  nurses for ESI   ***;
%macro process (d,n1,n2);
data &d ; set two;
if enid = &n1 or enid= &n2;run;
proc sort data=&d ;
    by epid; run;
**** here to create several column for each record using transpose procedure   for each pair of nurse ***;
proc freq data=&d noprint;
   tables Epid / out=eF&n1&n2 ; run;
proc sort data = ef&n1&n2;
   by epid; run;
data en&n1&n2;
  merge &d ef&n1&n2;
  by epid;   run;
proc sort data=en&n1&n2;
    by epid; run;
data ben&n1&n2;
   set en&n1&n2;
if count=2; run;
proc sort data=ben&n1&n2;
    by epid; run;
PROC TRANSPOSE DATA=ben&n1&n2
OUT=wen&n1&n2 (DROP=_NAME_ _LABEL_)
PREFIX=elevel;
BY epid;
VAR esi_calclevel; RUN;
proc sort data=wen&n1&n2; by  epid; run;
%mend process; run;
%process (three, 1,9);
%process (four, 5,12);
%process (five, 8,14);
%process(six, 10, 22);
%process (seven, 16, 24);
%process (eight, 17, 21);
run;
```

```
ods rtf; ods listing close;
%macro print (d,t);
proc print data=&d;
var  epid elevel1 elevel2  ;
title ' printing data / nurse ' &t;    run;
%mend print; run;
%print (wen19, 1 and 9);
%print (wen512, 5 and 12);
%print (wen814, 8 and 14);
%print (wen1022, 10 and 22);
%print (wen1624, 16 and 24);
%print (wen1721, 17 and 21);run;

%macro agree (d, t);
proc freq data=&d;
            tables elevel1*elevel2 / agree ;
      test AGREE;    exact agree/mc n=10000 alpha=.05;
 title ' frequency tables / Kappa Agreement/' &t;    run;
%mend agree; run;
%agree (wen19, 1 and 9);
%agree (wen512, 5 and 12);
%agree (wen814, 8 and 14);
%agree (wen1022, 10 and 22);
%agree (wen1624, 16 and 24);
%agree (wen1721, 17 and 21);
run;
ods rtf close; ods listing; quit; run;
```