**SEVERITY ANALYSIS USING RIDITS**

**© Copyright 2020, Mary A. Marion**

**Abstract.**

Ridit analysis was first introduced by Bross (1958) for the purpose of comparing ordinal scale responses. This article applies the technique to two sets of data to evaluate the severity of responses to toxic chemicals in animal bioassay experiments.

**1. Introduction**.

The endpoint selected in these studies is the number of animal subjects falling into severity codes (no disease, minimum, mild, moderate, and severe) by dose group samples.

Two data sets involving the effects of pesticides on rats were examined. Reported was the evaluation of severity of glomerulonephrophy in male rat kidneys with dose increments of a pesticide labeled X and a second evaluation of severity of mononuclear cell leukemia with dose increments of a second pesticide labeled Y.

The primary sampling unit is an animal subject, from it is determined a level of severity of injury based upon a continuous random variable which is divided into ordinal categories. Associated with each subject relative to the identified distribution is a numerical quantity (ridit). The ridit calculated for the jth severity code is the proportion of all subjects from the reference group falling at or below the midpoint of the jth severity code. The reference group can be the control group( see analysis 1) or a composite of all the dose groups (see analysis 2).

On the basis of the severity distributions found in Tables 1 and 2 on pages 7 and 8, a weighted ordered severity score called a mean ridit was calculated for each dose group. Mean ridits for the g dose groups are calculated as weighted averages of the ridits for the m individual severity categories.

A dose level’s mean ridit is an estimate of the probability that a randomly selected subject from it has a value on the underlying continuous variable greater than or equal to the value for a randomly selected subject from the (standard) reference group (Fleiss, 1986, p.81). It is an estimate of the chance that an subject in a given dose group is “worse off” than an subject in the reference group.

A generic SAS program was developed for use with multiple dose levels to calculate the ridits, group ridit means and their standard errors. Also computed are the overall population mean ridit, chi-square statistics to test hypotheses of equal mean ridits, and simultaneous tests of no dose difference with respect to the control dose. The reference group can be specified as either the population or the control group.

The pair-wise comparison of mean ridits of control and each dose group is evaluated by a chi-square statistic modified for the number of ties associated with each severity code. Individual and simultaneous confidence intervals are reported along with the odds of a dosed subject being worse off than a control subject.

**2. Statistical Theory**.

Ridit analysis is proposed as the method of choice for analyzing ordered categorical data. Bross [1958] developed the use of Ridit analysis for ordinally scaled data such as injury severity categories. A **ridit** is a numerical quantity (0 < ridit < 1); it is a transformation converting a severity classification into a number.

The only assumption made in ridit analysis is that the discrete categories represent intervals of an underlying but unobservable continuous distribution. No assumption is made about normality or any other form for the distribution. Ridit analysis begins with the selection of a population to serve as a standard or reference group.

We know that a given percentile is that value which divides the range of

a set of data into two parts such that a given percentage of the measures lies below this value. It is therefore a probability. Ridit analysis transforms ordinal data to a probability scale. The ridit score for each category is a percentile rank of a subject in the reference population and is equal to the number of subjects in all lower categories plus one-half the number of items in the subject category, all divided by the population size. Thus the ridit score given to a severity category is the relative frequency up to the midpoint of that category in the reference group.

Once the ridits for each category have been determined, they are considered as a dependent variable for the other comparison groups (Jairus Flora, 1974, page 2) and the usual normal probability distribution family of statistics can be applied in calculating means, standard deviations etc. The mean ridits calculated in this way will be approximately normal for reasonable sample sizes.

The mean ridit for the comparison group is determined as follows. If a subject X, is selected at random from the standard reference population (control group) and a subject Y, is selected at random from the comparison group, then the mean ridit is an estimate of P(X#Y), that is, of the probability that X is less seriously injured than Y. The reference group mean ridit is always .5 under this definition.

Let the reference group be group 1. This is in conformance to the SAS program RIDITS referenced in the bibliography. Let Pij be the proportion in severity category j=1...,k of the group I and define the ridit for a severity category by

j-1

Rj = 3 P1n + P1j/2 (2.1)

n=1

If X denotes the injury severity for a subject selected at random from the reference population, and Y denotes the injury severity for a subject within a particular group (dose), then the mean ridit for that group (dose)

\_ k

Ri = 3 Rj Pij (2.2)

j=1

can be interpreted as an estimate that a subject from the reference group would be in a less severe severity classification code than a dosed subject. More precisely,

(2.3)



The population mean ridit R is calculated as

(2.4)



It is the probability that for a subject selected at random from the population the subject would be in a less severe severity code level than a subject which has been dosed by a pesticide.

An approximate confidence interval using the standard error (s.e. or SE) of the mean ridit of a group of size is approximately (Fleiss, 1987, p.105)



(2.5)



The usual confidence interval for a mean ridit (Bross, 1956, page 7) is calculated as

(2.6)



The normal pdf statistic may be replaced by a t statistic in the case of small sample sizes.

Rough 95% confidence intervals on ridit means (Bross, 1958, page 24) are calculated as

(2.7)



Confidence intervals on average ridits involve the probability of a probability statement being true; it is a probability on the odds (Bross, 1956, page 8). The odds statement is expressed by the ratio (Kantor, 1968, page 613)

(2.8)



where d is the numerical difference between the average ridits of the groups being compared. Ridit differences are declared statistically significant when the 95% confidence limits of the two groups being compared do not intersect.

Comparisons between individual treatment groups is also possible. When comparing two groups without involving the reference group add .5 to the numerical differences of the two mean ridits (Bross, 1956, page 8). If are the mean ridits for group i and j, estimates the probability that a randomly selected member of group i has a value on the underlying variable greater than or equal to that of a randomly selected member of group j.



For example, let = .66. In terms of ridits the odds are about 2 to 1 that a dosed subject will sustain worse injury than a subject randomly selected from the control group one.



The average ridits are simply means of samples drawn from the rectangular distribution. The expected value of each mean is ½, the variance is 1/12N and the means are nearly normally distributed even in small samples.

The rectangular distribution on the interval from 0 to 1 has a mean of .5 and a variance of 1/12. The variance of the mean from this pdf based upon N observations is estimated by 1/12N. Thus

(2.9)



Between group comparisons on the basis of mean ridits have used t-tests and z-tests. The standard error for the difference of two mean ridits is given by

(2.10)



The significance of the difference between (individual contrast) for the large sample case may be tested by forming the statistic



(2.11)



The process of analyzing a sample data set using ridits is also analogous to ANOVA (Fleiss, 1986, page 81). An overall F-test of equal means is replaced by a chi-square test of "g equal mean ridits" with degrees of freedom varying as there are groups being compared. The test statistic is

(2.12)



where f is defined as

(2.13)



and represents the number of ties at the ith response. There are a total of T responses.



The significance of the difference between groups I and j may be tested simultaneously using a Scheffe`-type criterion. Compare the value of chi-square calculated from the empirical data withchi-square(g-1,α) where fij is the value of an adjustment factor calculated only on the frequencies of i and j combined. The Scheffe` Chi-Square test statistic for group comparisons is

(2.14)



where is defined as



(2.15)



and represents the number of ties at the ith response and .



For example, consider testing the significance of the difference between the control dose and hi-dose in table 1 (i.e. whether the estimated probability () of hi-dose is significantly different than .5. The number of ties in these two groups combined are



A typical Scheffe confidence interval testing the hypothesis of equal ridit means for groups i and j is given by

, where S = (2.16)



The probability is 1-α that the values of all contrasts simultaneously satisfy the inequalities

(2.17)



See Scheffe, 1959, page 67.

A second approach to confidence interval construction utilizes the so called Bonferroni Inequality which has the following theoretical basis (Mendenhall, 1990, page 624). For any events we have



(2.18)



From the additive law of probability we know that

. (2.19)



Therefore, it follows that

. (2.20)



Suppose that we want to find confidence intervals each covering 0 for parameters representing the m differences of treatment means minus control means where m = number of contrasts. Suppose that and let denote the event that is in . Then



(2.21)



A simultaneous confidence coefficient of at least (1-α) can be assured by choosing each ,j=1...m to have confidence coefficient 1-(α/m). This is a two-tailed test.



Adjust the level of significance () of each test to maintain a desired overall level α for the whole set of comparisons comprising the original null hypothesis. This goal can be achieved by using the so-called Bonferroni inequality with the α for an individual comparison is α/m where m is the number of comparisons.

A typical Bonferroni confidence interval (Fleiss, 1979, page 2082) testing the hypothesis of equal mean ridits for groups i and j is

(2.22)



where B is the corresponding critical normal curve value in the case of large sample sizes or the critical t curve value in the case of small sample sizes.

Ranges on the variance of the ridit scores in the reference population (Flora, 1974, page 2) depend on the shape of the distribution. Implicit is the assumption that the reference group is a population. Variance ranges are as follows

1. Reference Population

|  |  |
| --- | --- |
| In general | Variance of |
| Equal numbers in severity categories (Rectangular) | Variance of |
| Extremely skewed distributions | Variance of |

2. Comparison Group

Variance of



An ultra conservative test is (2.23)



**3. Statistical Application.**

In the following two examples, animals were exposed to pesticides and physiological changes were reported. Subjects were classified as to severity of symptoms.

**Analysis 1**.

In this analysis the reference group was taken to be the untreated control group one. SAS output for this study is presented in Table 1.

**Table 1**

GLOMERULONEPHROPATHY SEVERITY ANALYSIS -PESTICIDE X

Dose(ppm)

SEVERITY Group1 Group2 Group3 Group4 RIDIT

- no. Of subjects with -

none 5 5 7 4 0.03472

minimum 20 25 16 13 0.20833

mild 21 13 18 13 0.49306

moderate 16 14 12 14 0.75000

severe 10 15 19 28 0.93056

==== ==== ==== ====

72 72 72 72

Mn Mn Mn Mn Population

Ridit1 Ridit2 Ridit3 Ridit4 Ridit

0.5 0.50347 0.54350 0.63628 0.54581

Std1 Std2 Std3 Std4

0.03402 0.03402 0.03402 0.03402

95% Confidence Intervals on Individual Mean Ridits

Group MnRidit ROUGH USUAL ODDS

1 0.500 0.432, 0.568 0.384, 0.616 1.00:1

2 0.503 0.435, 0.572 0.387, 0.620 1.01:1

3 0.543 0.475, 0.612 0.428, 0.659 1.19:1

4 0.636 0.568, 0.704 0.524, 0.748 1.75:1

Scheffe` Analysis

Test of Equal Mean Ridits

Degrees

of

ChiSquare Freedom p\_value

10.97123 3 0.011882

Group1 vs Group2

Degrees

Scheffe` of

ChiSquare Freedom p\_value

.005492 3 0.99989

Group1 vs Group3

Degrees

Scheffe` of

ChiSquare Freedom p\_value

0.85590 3 0.83605

Group1 vs Group4

Degrees

Scheffe` of

ChiSquare Freedom p\_value

8.41275 3 0.038209

95% Simultaneous Confidence Intervals on Mean Ridits

Group Bonferonni Scheffe` Odds

2 0.388, 0.619 0.054, 0.953 1.01:1

3 0.428, 0.659 0.094, 0.993 1.19:1

4 0.521, 0.751 0.187, 1.086 1.75:1

The test for equal mean ridits is significant (p=.011882).

The average ridit for the 1st group (Rbar1) =.500 -> a randomly chosen subject in the control group of non dosed subjects is equally likely to be in a more severe injury category than the reference group. The subjects in dose group 2 are slightly more likely to be in a more severe injury category than the reference group of untreated subjects (p=.50357). The subjects in dose group 3 are even more likely to be in a more severe injury category than the reference group (p=.54350). Finally, the subjects in dose group 4 are more likely to be in a more severe injury category (p=.63628). Looking at the population as a whole, a randomly selected subject will be in a more severe injury category compared to the control group 1 with probability of .54581 (the population mean ridit).

Hypothesis testing on differences between dosed groups and control is not statistically significant for the dose groups 2 and 3. Dose group 4 however is statistically significantly different from the control group at the 5% level. Increasing the exposure to pesticide X increases severity of injury to the subjects in the study.

The odds of a randomly chosen subject in group I (i>1) of being worse off than a randomly chosen subject in reference group one are

Group Odds

2 1.01:1

3 1.19:1

4 1.75:1

The evaluation of severity of glomerulonephrophy in male rat kidneys with dose increments of the pesticide X resulted in a statistically significant difference in the comparison of the controls and the highest dose (1250 ppm) at the 05% level. The actual p\_value was 0.038209.

**Analysis 2.**

Analysis 2 combines the groups within each of the severity categories rather than using only the control group as the reference group. The population mean ridit in analysis 2 is .5 whereas in analysis 1 it was the control group whose mean ridit was .5. SAS output for this study is presented in Table 2.

**Table 2**

MONONUCLEAR CELL LEUKEMIA ANALYSIS - PESTICIDE Y

Dose(mg/kg)

SEVERITY Group1 Group2 Group3 RIDIT

- no. Of subjects with -

None 39 30 29 0.32667

Mild 4 5 2 0.69000

Moderate 2 5 9 0.78000

Severe 5 10 10 0.91667

==== ==== ====

50 50 50

Mn Mn Mn Population

Ridit1 Ridit2 Ridit3 Ridit

0.43287 0.52633 0.5408 0.5

Std1 Std2 Std3

0.04082 0.04082 0.04082

95% Confidence Intervals on Individual Mean Ridits

Group Rbar ROUGH USUAL ODDS

1 0.433 0.351, 0.515 0.294, 0.572 1.00:1

2 0.526 0.445, 0.608 0.387, 0.666 1.46:1

3 0.541 0.459, 0.622 0.401, 0.680 1.55:1

Scheffe` Analysis

Test of Equal Mean Ridits

Degrees

of

ChiSquare Freedom p\_value

5.72328 2 0.057175

Group1 vs Group2

Degrees

Scheffe` of

ChiSquare Freedom p\_value

3.88969 2 0.14301

Group1 vs Group3

Degrees

Scheffe` of

ChiSquare Freedom p\_value

5.08331 2 0.078736

95% Simultaneous Confidence Intervals on Mean Ridits

Group Bonferonni Scheffe` Odds

2 0.464, 0.723 0.168, 1.019 1.46:1

3 0.479, 0.737 0.182, 1.034 1.55:1

The mean ridit for the first group (.43287) is an indication of the probability that a randomly selected subject from group 1 (the control group) will have a more extreme value than a randomly selected subject from the reference group. Since this number is less than .5, we would infer that its subjects tend to have less extreme values than the subjects of the reference group. The test for equal mean ridits is significant at the 10% level (p=.057175).

The mean ridit for the second group (.52633) -> the subjects in dose group 2 are slightly more likely to be in a more severe injury category than the reference group of untreated subjects. Similarly the subjects in dose group 3 are more likely to be in a more severe injury category (p=.5408). The mean ridit of the population is .5 which is reasonable since the reference group of untreated subjects were comprised of subjects over all the treatment groups.

Hypothesis testing on differences between dosed groups and control is not statistically significant for the dose group 2. Dose group 3 however is statistically significantly different from the control group at the 10% level (p=.0788736).

The odds of a randomly chosen subject in group I (i>1) of being worse off than a randomly chosen subject in reference group one are

Group Odds

2 1.46:1

3 1.55:1

The evaluation of severity of mononuclear cell leukemia in male rats with dose increments of pesticide Y (Data Set # 2) resulted in a statistically significant difference in the comparison of the controls and the highest dose group at the 10% level. The actual p\_value was .078736 insignificant at the 5% level.

**4. Discussion.**

The statistical technique of ridit analysis was studied for its feasibility for use in environmental toxicity studies. The need for an alternative to the t-test and chi-square families of techniques arises because an ordered series of categories frequently cannot be laid out on an equal interval scale (Kantor, 1967, page 610). Severity analyses are often of this type.

A ridit is a numerical quantity which under appropriate conditions can serve as a measure of degree of injury. If ridits are being used solely for qualitative conclusions (such as would be obtained from tests of significance) one need not worry a great deal about the peculiarities of subjective scales. On the other hand, if one wants to derive quantitative results, the arithmetic mean of the ridits by severity category needs to be interpreted correctly.

For the identified distribution the mechanics of ridit analysis imposes a strong restriction (Bross, 1958, page 36). No matter what the nature of the original observations may be the mean ridits are usually uniformly distributed (the "rectangular distribution") with a uniform variance of 1/12. The sole exception occurs when nearly all of the observations fall into one or two categories(in which case a correction is needed to reduce the variance and the approximation is poorer). When the identified distribution departs from the true distribution, the true distribution will be a slightly distorted version of the rectangular distribution provided the reference set is moderately large.

Some classifications present particular difficulty. If the degrees of injury to subjects are recorded as slight, moderate, severe, disabling and fatal, there seems no entirely satisfactory way of placing the last two classes on the same scale as the first three.

The ridit transformation is an alternative to the probit transformation being based on an empirical rather than a theoretical distribution. The usual use of the two is different. The ridit is applied in cases where there are at least three ordered response categories, while the most frequent use of probits or logits is for a dichotomous response. Ridit analysis is primarily a test of differences in location. The application of probits would be analysis of a trend in proportions.

The choice to use ridit analysis requires knowledge of the subject matter, precise information about the data, a background in statistical methods and skill in the practice of statistics.

A graphical analysis of these data sets is included as figures 1 and 2.





**5. Suggested Protocol**

A suggested protocol for the execution of a ridit analysis for a dose/response data set is as follows.

**Step 1**

Rank the entire data sets response variable over all doses.

**Step 2**

Determine the severity code ranges based upon the ranks. For example consider the situation where there are 70 observations, 70/5=14. Now assign each observation a severity code using cutoff points 14,28,42,56,70. A sample table might look like

Severity Code Ranges (N=14)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Dose | 1-14 | 15-28 | 29-42 | 43-56 | 57-70 |
| 0 | 6 | 7 | 3 | 2 | 2 |
| 3 | 2 | 2 | 4 | 5 | 5 |
| 6 | 5 | 3 | 4 | 2 | 5 |
| 12 | 1 | 2 | 3 | 5 | 2 |

**Step 3**

Perform a ridits analysis.

**6. Acknowledgements**.

Although the research described in this article has been funded wholly by the U.S. Environmental Protection Agency, it has not been subjected to Agency review. Therefore, it does not necessarily reflect the views of the Agency.

SAS is a registered trademark of SAS Institute Inc. in the USA and other countries. Analyses and development were done using Windows 3.1 and Windows 95 operating systems and SAS versions 6.11, 6.12. Code is operable in version 8.1 on a Windows 98 platform.

Author Contact: Mary A. Marion, 4920 Carriagepark Road, Fairfax, Virginia e-mail:mmstat@erols.com. Voice: 703-978-8979.

**7. Bibliography.**

Bross, Irwin D.J. (1958), How to Use Ridit Analysis, Biometrics Number 1, Volume 14, pages 18-38.

Bross, Irwin D.J. (1978), Ridit Analysis, American Journal of Epidemiology v107, pages 263-264.

Bross, Irwin D. J. (1956), Ridit Analysis of Automotive Crash Injuries, Cornell University Medical College, Department of Public Health and Preventive Medicine, Division of Automotive Crash Injury Research.

Bross, Irwin D. J. (1979), Ridit Analysis and Ranking Procedures: Reply on Biases in Judging Statistical Methods, Amerian Journal of Epidemiology, v109, pages 30-32.

Chilton, Neal W. (1982), Design and Analysis in Dental and Oral Research, 2nd Edition, Praeger Publishing Company: New York.

Cochran, William G. (19xx), Statistical Methods -Sixth Edition, The Iowa State University Press: Ames, Iowa, page 246.

Fleiss, Joseph L.(1986), The Design and Analysis of Clinical Experiments, pages 76-90, John Wiley and Sons: New York, New York.

Fleiss, Joseph L.(1983), Statistical Methods for Rates and Proportions, pages 92-108, John Wiley and Sons: New York, New York.

Fleiss, Joseph L., Chilton, Neal W. and Wallenstein, Sylvan (Nov 1979), Ridit Analysis in Dental Clinical Studies, Journal of Dental Research Volume 58, pages 2080-2084.

Flora Jr., Jairius D. (1974), A Note on Ridit Analysis -Biostatistics Technical Report Series No. 3, Department of Biostatistics, School of Public Health and Highway Safety Research Institute, University of Michigan: Ann Arbor, Michigan 48104, U.S.A.

James, Robert C. & James, Glenn (1968), Mathematics Dictionary -Third Edition, page 268, Van Nostrand Reinhold Company: New York, New York.

Kantor, S, Winklestein, W. And Ibrahim, M.A. (1968), A Note on the Interpretation of the Ridit as a Quantile Rank, American Journal of Epidemeology -Volume 87, pages 609-615.

Kotz, Samuel, Johnson, Norman L. and Read, Campbell B. (1982), Encyclopedia

of Statistical Science, V8, pages 136-139, John Wiley and Sons: New York,

New York.

Mahler, David B., Terkla, Louis G. and Van Eysden, Jan (1973), Journal of Dental Research, July-August.

Mahler, David B., Terkla, Louis G., Van Eysden, Jan and Reisbick, Morris H. (1970), Marginal Fracture vs Mechanical Properties of Amalgam, Journal of Dental Research 49: 1452-1457..

Mantel, Nathan (1979), Ridit Analysis and Related Ranking Procedures -Use at Your Own Risk, American Journal of Epidemiology published by The Johns Hopkins University School of Hygiene and Public Health.

Marion, Mary (1996), Severity Analysis Using Ridits, Proceedings of the Twenty-First Annual SAS Users Group International Conference, March 10-13, pages 957-969.

Mendenhall, William, Wackerly, Dennis D. and Scheaffer, Richard L. (1990), Mathematical Statistics with Applications -Fourth Edition, PWS-Kent Publishing Company: Boston, Massachusetts, pages 624-626.

SAS Language: Reference, Version 6, First Edition, SAS Institute Inc.: SAS Campus Drive, Cary, North Carolina, page 491.

Scott, R.E., Flora, J.D., and Marsh, J.C. (1976), An Evaluation of the 1974 and 1975 Restraint Systems, Highway Safety Research Institute, University of Michigan: Ann Arbor, Michigan.

Scheffe`, H. (1959), Analysis of Variance, John Wiley & Sons, New York, New York, pages 66-67.

Selvin, Steve (1977), A Further Note on the Interpretation of Ridit Analysis, American Journal of Epidemeology -Volume 105, pages 16-20.

Spiegel, Murray R.(1961), Statistics -Schaums’s Outline Series, McGraw-Hill Book Company, page 143.

Spitzer, Robert L., Fleiss, Joseph, Kernohan, William, Lee, Joan C. and Baldwin, Ingram T. (1965), Mental Status Schedule: Comparing Kentucky and New York Schizophrenics, Archives of General Psychiatry, Volume 12, pages 448-455.

Wynder, Ernest L., Bross, Irwin J. And Hirayama, Takeshi (1960), A Study of the Epidemeology of Cancer of the Breast, Cancer Volume 13, pages 559-601.

**8.** **SAS Code.**

The SAS code developed to analyze the above data sets is below. Both

call the macro ridits for the ridit analysis. Inputs to the macro are explained in the beginning of the macro itself.

**Data set #1**.

%let mtitle=

%str(GLOMERULONEPHROPATHY SEVERITY ANALYSIS -PESTICIDE X));

title1 &mtitle;

%let nogrp=4;

%let codeno=5;

%let compgrp=2;

%let one=sum(of Grp1-Grp&nogrp);

data d;

input severity $ Grp1-Grp&nogrp @@;

one=&one;

cards;

none 05 05 07 04

minimum 20 25 16 13

mild 21 13 18 13

moderate 16 14 12 14

severe 10 15 19 28

;

%ridits(d,&nogrp,&codeno,&mtitle,&one);

**Data set #2**

%let mtitle=

%str(MONONUCLEAR CELL LEUKEMIA SEVERITY ANALYSIS -Data Set 2);

title1 &mtitle;

%let nogrp=3;

%let codeno=4;

%let compgrp=2;

%let one=sum(of Grp1-Grp&nogrp);

data d;

input severity $ Grp1-Grp&nogrp @@;

one=&one;

cards;

code0 39 30 29

code1 04 05 02

code2 02 05 09

code3 05 10 10

;

%ridits(d,&nogrp,&codeno,&mtitle,&one);

**SAS MACROS**

**%macro** sysgraph(GTYPE,filename);

%if &GTYPE=%str(WINWP8L) and &SYSSCP=%str(WIN) %then %do;

goptions reset=all;

filename gsasfile clear;

filename gsasfile "c:\mydata\&filename..cgm";

goptions device=CGMWP80L

display noswap prompt nosymbol nopolygonfill

/\* cback=white colors=(black)

rotate=landscape hsize=0in vsize=0in \*/

gaccess=gsasfile gsfmode=replace;

%end; %else

%if &GTYPE=%str(WIN) and &SYSSCP=%str(WIN) %then %do;

filename gsasfile clear;

goptions reset=all;

goptions fby=simulate ftext=simulate ftitle=simulate;

goptions device=WIN targetdevice=WIN;

%end; %else

%if &GTYPE=%str(WINPRTM) and &SYSSCP=%str(WIN) %then %do;

filename gsasfile clear;

goptions reset=all;

goptions fby=simulate ftext=simulate ftitle=simulate;

options sysprintfont='Courier New' **10**;

goptions horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in;

goptions device=WIN targetdevice=WINPRTM

display noswap noprompt cback=white colors=(black)

rotate=landscape horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in

gsflen=**80** gsfmode=replace;

%end; %else

%if &GTYPE=%str(DIRECT) and &SYSSCP=%str(WIN) %then %do;

filename gsasfile clear;

goptions reset=all;

goptions fby=simulate ftext=simulate ftitle=simulate;

options sysprintfont='Courier New' **10**;

goptions horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in;

/\* goptions device=WINPRTM sends graphics output directly to the printer \*/

goptions device=WINPRTM targetdevice=WINPRTM

display noswap noprompt cback=white colors=(black)

rotate=landscape horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in

gsflen=**80** gsfmode=replace;

%end; %else

%if &GTYPE=%str(LQ2550) and &SYSSCP=%str(WIN) %then %do;

filename gsasfile clear;

filename gsasfile "c:\mydata\&filename..cgm";

goptions reset=all;

goptions fby=simulate ftext=simulate ftitle=simulate;

options sysprintfont='Courier New' **10**;

goptions horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in;

goptions device=LQ2550 targetdevice=LQ2550

display noswap noprompt cback=white colors=(black)

rotate=landscape horigin=**1** vorigin=**1** hsize=**9**in vsize=**6.5**in

gsflen=**80** gsfmode=replace;

%end;

**%mend** sysgraph;

**%macro** compGroup(compGroup);

/\* TIE Group and Fij Statistic Calculations \*/

/\* Fleiss, Design and Analysis of Clinical Experiments

page 77 (3.37) \*/

data fij; set ridit;

keep dum tie ndot fnum1 fdenom1 sum1-sum&noGroup

ndot MnRidit1-MnRidit&noGroup;

tie=Group1+Group&compGroup;

ndot=sum1+sum&compGroup;

fnum1=tie\*(tie-**1**)\*(tie+**1**);

fdenom1=ndot\*(ndot-**1**)\*(ndot+**1**);

%***mmeans2***(fij,fnum1,sum);

data fij; merge fij meansout; by dum; drop sum;

fnum=sum;

%***mmeans2***(fij,fdenom1,max);

data fij; merge fij meansout; by dum; drop max;

fdenom=max;

Fij=**1**-(fnum/fdenom);

data scheffe; set fij; format Chi **10.5**;

if \_N\_ > **1** then delete;

/\* Fleiss, Design and Analysis of Clinical Experiments

page 82 (3.43) \*/

above=**12** \* sum1 \* sum&compGroup \* (MnRidit1-MnRidit&compGroup)\*\***2**;

below = ( sum1 + sum&compGroup + **1**) \* Fij;

Chi=above/below;

df=&noGroup-**1**;

p\_value=**1**-probchi(Chi,df);

/\* OUTPUT of Scheffe ChiSquare \*/

title;

proc print data=scheffe split='\*' noobs; var Chi df p\_value;

label Chi="Scheffe`\*ChiSquare" df='Degrees\*of\*Freedom'

p\_value='p\_value' ;

title "Group1 vs Group&compGroup"; run;

title;

**%mend** compGroup;

**%macro** dosums(codeno);

%local i ii stop;

data td; set td; keep sum1-sum&codeno;

sum1=**0**;

sum2=sum(col1);

%let stop=&codeno+1;

%do i=**3** %to &stop;

%do ii=&i-**2** %to &i-**2**; %end;

sum&i=sum(of col1-col&ii);

%end;

**%mend** dosums;

**%macro** equalmns(noGroup);

/\* TIE Group and F Statistic Calculations \*/

/\* Fleiss, Design and Analysis of Clinical Experiments

page 77 (3.37) and page 82 (3.42) \*/

data f; set ridit;

keep dum tie ndot fnum1 fdenom1 sum1-sum&noGroup

ndot MnRidit1-MnRidit&noGroup PopulationRidit tot;

tie=sum(of Group1-Group&noGroup);

fnum1=tie\*(tie-**1**)\*(tie+**1**);

fdenom1=ndot\*(ndot-**1**)\*(ndot+**1**);

%do j=**1** %to &noGroup;

comp&j = sum&j \* (MnRidit&j-PopulationRidit)\*\***2**;

%end;

tot=sum(of comp1-comp&noGroup);

%***mmeans2***(f,fnum1,sum);

data f; merge f meansout; by dum; drop sum;

fnum=sum;

%***mmeans2***(f,fdenom1,max);

data f; merge f meansout; by dum; drop max;

fdenom=max;

F=**1**-(fnum/fdenom);

data equalmns; set f; format Chi **10.5**;

if \_N\_ > **1** then delete;

/\* Fleiss, Design and Analysis of Clinical Experiments page 82 (3.42)

\*/

above=**12** \* ndot \* tot;

below = ( ndot + **1**) \* F;

Chi=above/below;

df=&noGroup-**1**;

p\_value=**1**-probchi(Chi,df);

/\* OUTPUT of Scheffe` Test of Equal Means ChiSquare \*/

proc print data= equalmns split='\*' noobs; var Chi df p\_value;

label Chi="ChiSquare" df='Degrees\*of\*Freedom' p\_value='p\_value' ;

title1 "Scheffe` Analysis";

title2 "Test of Equal Mean Ridits"; run; quit; title;

**%mend** equalmns;

**%macro** grafit(noGroup,alpha);

%***sysgraph***(WINWP8L,ci);

data grafit; set interval; keep MnRiditL MnRidit MnRiditU group;

%local i;

%do i=**1** %to &noGroup;

/\* MnRiditL=usualL&i; MnRiditL=SchefL&i; \*/

/\* MnRiditU=usualU&i; MnRiditU=SchefU&i; \*/

MnRiditL=BonL&i;

MnRidit=MnRidit&i;

MnRiditU=BonU&i;

Group=&i;

output;

%end;

data grafit; set grafit;

confid1=**1**-&alpha;

confid2=put(confid1,**3.2**);

confid3=substr(confid2,**2**);

call symput('conlim',trim(confid3));

run;

proc print data=grafit noobs;

title "grafit"; run cancel;

goptions reset=(symbol axis footnote legend);

proc gplot data=grafit;

title1 h=**2.75** "&mtitle";

footnote justify=center h=**2.0** "&conlim% Bonferroni Confidence Intervals";

plot (MnRiditL MnRidit MnRiditU) \* group / haxis=axis1 vaxis=axis2 overlay;

symbol1 v=diamond h=**2** l=**2** c=blue;

symbol2 v=dot h=**2** l=**2** c=red;

symbol3 v=square h=**2** l=**2** c=green;

axis1 minor=none /\* order = 0 to 5 by 1 \*/

offset=(**2**,**2**) label=(h=**2.5** f=complex c=black "Group");

axis2 minor=none order = **0** to **1** by **.10**

label=(h=**2.5** a=-**90** r=**90** f=complex c=black "Mean Ridit");

run;

goptions reset=(symbol axis footnote legend);

**%mend** grafit;

**%macro** ***group***;

%local j;

%do j=**1** %to &noGroup;

%***mmeans2***(ridit,Group&j,sum);

data ridit; merge ridit meansout; by dum;

data ridit; set ridit; drop sum;

sum&j=sum;

product&j=Group&j\*ridit;

%***mmeans2***(ridit,product&j,sum);

data ridit; merge ridit meansout; by dum;

data ridit; set ridit; drop sum;

sumprod&j=sum;

MnRidit&j=sumprod&j/sum&j;

Std&j=**1**/(**2**\*sqrt(**3**\*sum&j));

wtMnRidit&j=sum&j\*MnRidit&j;

%end;

data ridit; set ridit;

ndot=sum(of sum1-sum&noGroup);

PopulationRidit=sum(of wtMnRidit1-wtMnRidit&noGroup)/ndot;

**%mend** group;

**%macro** interval(noGroup,alpha);

data interval; set ridit;

%local i;

quanparm=**1**-(&alpha/**2**);

quantile=probit(quanparm);

%do i=**1** %to &noGroup;

diff&i = **1**-MnRidit&i;

sqval1&i = (MnRidit&i \* diff&i) / ( sum&i-**1** );

sqval&i = sqrt(sqval1&i);

usual&i = quantile \* sqval&i;

usualL&i = MnRidit&i - usual&i;

usualU&i = MnRidit&i + usual&i;

roughL&i = MnRidit&i - **1** / sqrt(**3**\*sum&i);

roughU&i = MnRidit&i + **1** / sqrt(**3**\*sum&i);

odds&i = ( **0.5** + ( MnRidit&i-MnRidit1 ) ) /

( **1** - ( **0.5** + (MnRidit&i-MnRidit1) ) );

%end;

data interval; set interval; if \_n\_ > **1** then delete;

keep MnRidit1-MnRidit&noGroup diff1-diff&noGroup

usualL1-usualL&noGroup usualU1-usualU&noGroup

roughL1-roughL&noGroup roughU1-roughU&noGroup

odds1-odds&noGroup quantile sum1-sum&noGroup;

data interval; set interval; drop quanparm;

%local i;

%do i=**1** %to &noGroup;

num&i = sqrt(sum&i+sum1);

den&i = **2**\*sqrt(**3**\*sum&i\*sum1);

se&i = num&i/den&i;

paramter = **1**- (&alpha / (**2**\* (&noGroup-**1**) ) );

B = probit(paramter);

paramter = &noGroup-**1**;

quanparm = **1**- (&alpha/**2**);

S = cinv(quanparm, paramter);

BonL&i = MnRidit&i-MnRidit1+**.5** - B\*se&i;

BonU&i = MnRidit&i-MnRidit1+**.5** + B\*se&i;

SchefL&i = MnRidit&i-MnRidit1+**.5** - S\*se&i;

SchefU&i = MnRidit&i-MnRidit1+**.5** + S\*se&i;

%end;

data interval; set interval;

%global conlim;

confid1=**1**-&alpha;

confid2=put(confid1,**3.2**);

confid3=substr(confid2,**2**);

call symput('conlim',trim(confid3));

run;

data interval; set interval;

file print;

put " "

" &conlim% Confidence Intervals on Individual Mean Ridits"

/;

put " " "Group" " MnRidit "

" ROUGH " " USUAL"

" ODDS" / ;

%do i= **1** %to &noGroup;

ii=&i;

put " " ii **5.0**

MnRidit&i **10.3**

roughL&i **09.3** "," roughU&i **06.3**

usualL&i **09.3** "," usualU&i **06.3**

odds&i **08.2** ":1";

%end;

run;

**%mend** interval;

**%macro** mmeans2(dsname,varlst,stat);

proc datasets library=work; delete meansout; run;

proc means data=&dsname noprint;

var &varlst;

output out=meansout

n=n nmiss=nmiss mean=mean Std=Std min=min max=max range=range

sum=sum var=var uss=uss css=css Stderr=Stderr cv=cv

/\* skewness=skewness kurtosis=kurtosis sumwgt=sumwgt \*/

t=t prt=prt;

run;

data meansout; set meansout;

dum=**1**;

keep &stat dum; run;

**%mend** mmeans2;

**%macro** ***myprints***;

options formdlim='';

title1;

data \_null\_; file print; put \_page\_; run;

title1 &mtitle;

proc print data=ridit noobs;

var severity Group1-Group&noGroup one two three four ridit

product1-product&noGroup sum1-sum&noGroup sumprod1-sumprod&noGroup

MnRidit1-MnRidit&noGroup Std1-Std&noGroup wtMnRidit1-wtMnRidit&noGroup ndot

PopulationRidit;

title2 "Calculations -&noGroup Groups"; run;

options formdlim='';

title1 &mtitle;

proc print data=fij; title2 'fij'; run;

proc print data=scheffe noobs; title2 "scheffe`"; run ;

options formdlim='';

title1 &mtitle;

proc print data=f noobs; title2 'f' ; run ;

proc print data=equalmns noobs; title2 "equalmns"; run ;

proc print data=interval noobs;

var MnRidit1-MnRidit&noGroup diff1-diff&noGroup

usualL1-usualL&noGroup usualU1-usualU&noGroup

roughL1-roughL&noGroup roughU1-roughU&noGroup

odds1-odds&noGroup quantile sum1-sum&noGroup

num2-num&noGroup den2-den&noGroup se2-se&noGroup;

title2 "interval"; run;

**%mend** myprints;

**%macro** ridits(DataFile,noGroup,codeno,alpha,diagnose,mtitle,one);

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

\* RIDIT ANALYSIS written July 22,1995 and \*

\* modified June, 1996,1997, 1998 \*

\* \*

\* (C) Copyright Mary A. Marion, Jan 12, 1998 \*

\* \*

\* Inputs: \*

\* \*

\* NOGroup = Number of groups \*

\* CODENO = No of severity codes (levels) \*

\* ALPHA = Significance Level such as .05 \*

\* DIAGNOSE = Diagnostic print indicator (Yes or No) \*

\* MTITLE = title of the experiment \*

\* DSNAME = Input data matrix of severity codes by group \*

\* ONE = reference population \*

\* \*

\* Constraints: \*

\* \*

\* Scheffe'-type comparisons between groups always compare to Group1. \*

\* Thus always enter the control group as Group1 when not combining \*

\* across all groups to form the reference population. \* \*

\* all groups to form the reference population \*

\* \*

\* Macros called: compGroup, dosums, equalmns, group, interval, \*

\* mmeans2, myprints \*

\* \*

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* \*/

data timetrak;

time1=time();

data DataFile; set &DataFile;

one=&one;

two=one/**2**;

/\* THREE (Column 3) Computation \*/

proc transpose data=DataFile out=td; var one; run;

%***dosums***(&codeno);

proc transpose data=td out=td2; var sum1-sum&codeno; run;

data ridit; merge td2 DataFile; rename col1=three;

keep severity one two col1 dum Group1-Group&noGroup;

dum=**1**;

run;

/\* RIDIT Calculations \*/

%***mmeans2***(ridit,one,sum);

data ridit; merge ridit meansout; by dum;

data ridit; set ridit; drop sum;

sum0=sum;

four=two+three;

ridit=four/sum0;

/\* GROUP CALCULATIONS \*/

%***group***;

/\* OUTPUT of table of dose group X severity levels +

ridits for the severity categories \*/

data \_null\_; file print; put \_page\_; run;

options formdlim='';

options nonumber;

proc print data=ridit noobs;

var severity Group1-Group&noGroup /\* one \*/ ridit;

sum Group1-Group&noGroup /\* one \*/;

title &mtitle; run;

/\* OUTPUT of MnRidits, Population Mean Ridit and

standard errors of MnRidits \*/

data riditout; set ridit; if \_n\_ > **1** then delete;

format Std1-Std&noGroup **7.5**;

options formdlim=' ';

title;

proc print data=riditout noobs;

var MnRidit1-MnRidit&noGroup PopulationRidit;

run;

proc print data=riditout noobs;

var Std1-Std&noGroup;

run;

/\* CONFIDENCE INTERVALS on the RIDIT MEANS \*/

%***interval***(&noGroup,&alpha);

/\* TESTING the HYPOTHESIS of EQUAL MEAN RIDITS \*/

%***equalmns***(&noGroup);

/\* (G-1) SCHEFFE`-type GROUP COMPARISONS to the control group (Group1)

\*/

**%macro** generate(noGroup);

%do i=**2** %to &noGroup;

%***compGroup***(&i); %end;

**%mend**;

%***generate***(&noGroup);

/\* Table of Confidence Intervals and Odds \*/

data interval; set interval;

file print;

put " &conlim% Simultaneous Confidence Intervals on Mean

Ridits" /;

put " "

"Group" " Bonferonni" " Scheffe`" " Odds";

%do i=**1** %to &noGroup;

ii=&i;

put " " ii **3.0** " "

BonL&i **10.3** "," BonU&i **6.3**

SchefL&i **10.3** "," SchefU&i **6.3**

odds&i **08.2** ":1";

%end;

run;

/\* Graphical Analysis \*/

%***grafit***(&noGroup,&alpha);

/\* Output of Intermediate Calculations \*/

%if &DIAGNOSE=No %then %goto TRAK;

%else

%if &DIAGNOSE=Yes %then %do;

%***myprints***;

%end;

%TRAK:

title1; title2; title3;

data timetrak; set timetrak;

time2=time();

Xtime=(time2-time1)/**60**;

file print;

put \_page\_ ;

put // "Total Execution Time is " xtime **5.3** " Minutes";

proc datasets;

delete DataFile td td2 meansout ridit riditout fij scheffe

f equalmns interval grafit timetrak;

run; quit;

**%mend** ridits;

**SAS INPUTS**

%let mtitle=%str(GLOMERULONEPHROPATHY SEVERITY ANALYSIS -PESTICIDE X);

title1 &mtitle;

%let noGroup=4;

%let codeno=5;

%let one=Group1;

data d;

input severity $ Group1-Group&noGroup @@;

one=&one;

cards;

none 05 05 07 04

minimum 20 25 16 13

mild 21 13 18 13

moderate 16 14 12 14

severe 10 15 19 28

;

%*ridits*(d,&noGroup,&codeno,.05,No,&mtitle,&one);

%let mtitle=%str(MONONUCLEAR CELL LEUKEMIA ANALYSIS -Pesticide Y);

title1 &mtitle;

%let noGroup=3;

%let codeno=4;

%let one=sum(of Group1-Group&noGroup);

data d;

input severity $ Group1-Group&noGroup @@;

one=&one;

cards;

none 39 30 29

mild 04 05 02

moderate 02 05 09

severe 05 10 10

;

%*ridits*(d,&noGroup,&codeno,.05,No,&mtitle,&one);

%let mtitle=%str(1974 Transportation Study -Reference Group is Population);

title1 &mtitle;

%let noGroup=2;

%let codeno=4;

%let one=sum(of Group1-Group&noGroup);

data d;

input severity $ Group1-Group&noGroup @@;

one=&one;

cards;

none 357 417

minor 540 330

moderate 53 33

serious 35 17

;

%*ridits*(d,&noGroup,&codeno,.05,No,&mtitle,&one);

%let mtitle=%str(1974 Transportation Study -Reference Group is Group1);

title1 &mtitle;

%let noGroup=2;

%let codeno=4;

%let one=Group1;

data d;

input severity $ Group1-Group&noGroup @@;

one=&one;

cards;

none 357 417

minor 540 330

moderate 53 33

serious 35 17

;

%*ridits*(d,&noGroup,&codeno,.05,No,&mtitle,&one);

**9.** **RIDITS PROTOCOL WITH SAS CODE.**

**Step 1**

Rank the entire data set=s response variable over all doses.

Sample code is:

/\* Rank of an observation is to be stored in overall \*/

proc rank data=DataSet descending out=ranks;

var response; ranks overall; run;

/\* Reduce the data set to what I need for a ridits analysis \*/

data ranks; set ranks;

keep dose block response overall;

proc print data=ranks;

title "ranks print"; run cancel;

/\* Sort the data set containing the ranks by dose and rank \*/

proc sort data=ranks out=sortrank;

by dose overall; run;

proc print;

title "sortrank"; run;

**Step 2**

Determine the severity code ranges based upon the ranks. For example consider the situation where there are 70 observations, 70/5=14. Now assign each observation a severity code using cutoff points 14,28,42,56,70. A sample table might look like

Severity Code Ranges (N=14)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Dose | 1-14 | 15-28 | 29-42 | 43-56 | 57-70 |
| 0 | 6 | 7 | 3 | 2 | 2 |
| 3 | 2 | 2 | 4 | 5 | 5 |
| 6 | 5 | 3 | 4 | 2 | 5 |
| 12 | 1 | 2 | 3 | 5 | 2 |

**Step 3**

Run the SAS ridits code to perform ridits analysis.