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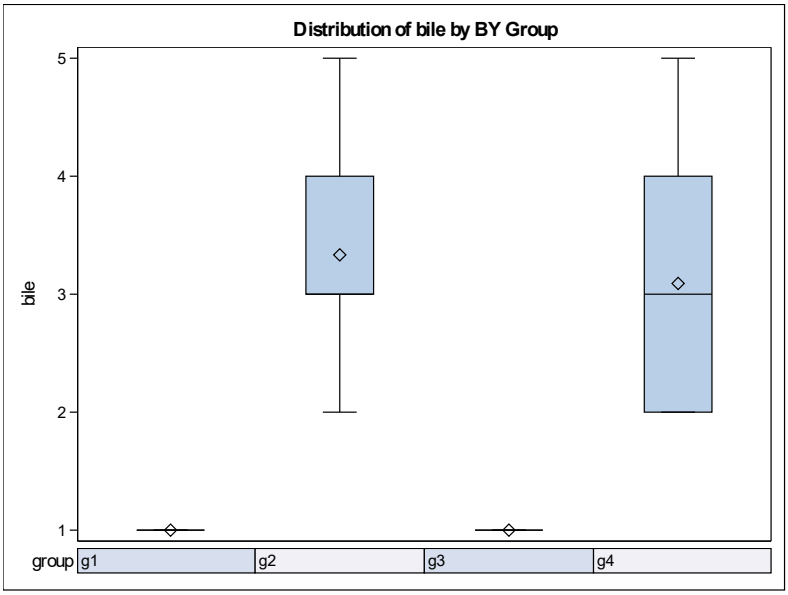
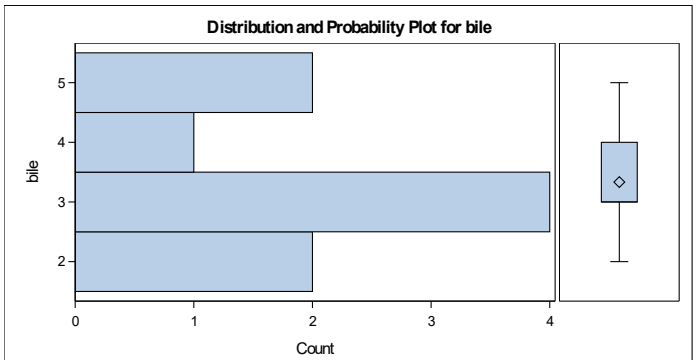
Biostatistics
Homework 2
Due: 2/9/18

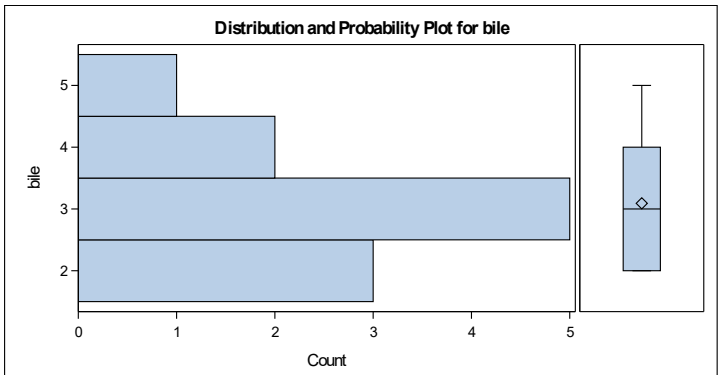
1. Create a visual summary that meaningfully compares the distribution of the scores in each group

   * Note: Histograms were not created for groups 1 and 3 because both groups only contained one level of severity (level 1).





Distribution for Group 2



Distribution for Group 4

2. Test whether the Group IV scores are much different than 3 using:
    a. A parametric method.
    Method: One-sample t-test
    Hypotheses: H_0: $\mu = 3$ vs H_A: $\mu \neq 3$
    Test statistic: 0.32
    P-value: 0.7560
    Conclusion: We fail to reject H_0. These data show no evidence that the severity scores in group 4 are much different from 3 ("Mild – evident but not widespread").

    b. A nonparametric method.
    Method: Wilcoxon Signed Rank test
    Hypotheses: H_0: $\mu = 3$ vs H_A: $\mu \neq 3$
    Test statistic: 1.5
    P-value: 1.00
    Conclusion: Fail to reject H_0. We have no evidence in these data that the severity scores in group 4 are much different than 3.

3. Test whether the Group IV scores are much different than the Group III scores using:
    a. A parametric method.
    Method: 2-sample t-test
    Hypotheses: H_0: $\mu_3 = \mu_4$ vs H_A: $\mu_3 \neq \mu_4$
        * Note: because the equality of variances test was significant ($p < 0.0001$), the Satterthwaite adjustment was used.
    Test statistic: -7.35
    P-value: < 0.0001
    Conclusion: We reject H_0. There is very strong evidence that the severity scores in group 3 are very different from the scores in group 4.

    b. A nonparametric method.
    Method: Wilcoxon Rank Sum (aka Mann-Whitney test)
    Hypotheses: H_0: $\mu_3 = \mu_4$ vs H_A: $\mu_3 \neq \mu_4$
    Test statistic: 55.0
    P-value: < 0.0001 (Two-Sized Pr > |Z|)
    Conclusion: We would again reject H_0. We have very strong evidence that the severity scores in group 3 are very different from the scores in group 4.

4. Test whether the scores are much different among groups using:
    a. A parametric method.
    Method: One-way ANOVA

Hypotheses: H_0: $\mu_i = \mu$ for i = 1,2,3,4 vs H_A: $\mu_i \neq \mu$ for some i

* Note: The test for homogeneity of variance was significant (p = 0.0021), so Welch's ANOVA was used.

Test statistic: 0.27
P-value: 0.6123
Conclusion: We fail to reject H_0. We did not find evidence that the scores are significantly different across the four groups.

b. A nonparametric method.
Method: Kruskal-Wallis test
Hypotheses: H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ vs H_A: $\mu_i \neq \mu_j$ for some i,j
Test statistic: 34.0314
P-value: < 0.0001
Conclusion: Reject H_0. We have found strong evidence that there is a significant difference between the severity scores in at least two of the groups.

5. Discuss which method (parametric or nonparametric) is most appropriate in exercises 2-4 and why.

Exercise 2: The non-parametric method (Wilcoxon Signed-Rank test) is more appropriate. Parametric assumptions not met.
Exercise 3: The non-parametric method (Wilcoxon Rank-Sum test) is more appropriate. Parametric assumptions not met.
Exercise 4: The non-parametric method (Kruskal-Wallis test) is more appropriate. Parametric assumptions not met.

The reason for the non-parametric methods being more appropriate is the same in all three cases. The data that we were examining cannot be assumed to follow a normal distribution. One could maybe argue that the data from group 4 follows a normal distribution. However, group 2 clearly does not follow a normal distribution as it shows signs of bi-modality. Likewise, groups 1 and 3 do not follow a normal distribution because all observations in these groups have the same value. Another reason to be skeptical of normality in these data is that the observations are on a 5-point ordinal scale.

Because these data do not meet the assumption of approximate normality, non-parametric methods are safer and more appropriate to use.

Appendix – SAS Code

```
/* Biostatistics - Homework 2 */

data poultry;
input group $ severity @@;
cards;
g1 1 g1 1 g1 1 g1 1 g1 1 g1 1 g1 1 g1 1 g1 1 g1 1 g1 1
g2 5 g2 3 g2 5 g2 3 g2 2 g2 3 g2 2 g2 4 g2 3
g3 1 g3 1 g3 1 g3 1 g3 1 g3 1 g3 1 g3 1 g3 1 g3 1
g4 3 g4 2 g4 3 g4 2 g4 3 g4 4 g4 3 g4 3 g4 2 g4 5 g4 4
;
run;

proc print data = poultry;
run;

/* 1. Create a visual summary that meaningfully compares
the distribution of the scores in each group */
proc univariate data = poultry plots;
by group;
var severity;
run;

/* 2(a) One-sample t-test */
proc ttest data = poultry HO = 3;
where group = 'g4';
var severity;
title1 'One-sample t-test';
run;

/* 2(b) One-sample non-parametric test (Wilcoxon Signed Rank) */
proc univariate data = poultry mu0 = 3;
where group = 'g4';
var severity;
title1 'Wilcoxon Rank-Sum';
run;

/* 3(a) Two-sample t-test */
proc ttest data = poultry;
where group = 'g3' | group = 'g4';
class group;
var severity;
title1 'Two-sample t-test';
```

```
run;

/* 3(b) Wilcoxon Rank Sum test */
proc npar1way wilcoxon data = poultry;
where group = 'g3' | group = 'g4';
class group;
var severity;
title1 'Wilcoxon Rank-Sum Text';
run;

/* 4(a) One-way ANOVA */
proc glm data = poultry;
class group;
model severity = group;
meas group / hovtest = BF welch;
title1 'One-way ANOVA';
run;

/* 4(b) Kruskal-Wallis test */
proc npar1way wilcoxon data = poultry;
class group;
var severity;
title1 'Kruskal-Wallis test';
run;
```