Session 6

Administrivia

- Logistical issues:
  - Final examination:
    - December 16, 4:30pm-7pm Eastern time
    - Makeup: December 17, 4:30am-7am Eastern time
      TOTALLY different examination
  - Assignment 5
    - Available 7pm Eastern time today
    - Due December 9, 4:25pm-7pm Eastern time

Review From Our Last Discussion

In much the same way that multiple regression results qualify the results of a simple linear regression, n-way ANOVA results can qualify the results of a one-way ANOVA;

When we have more than one discrete independent variable, we can still meaningfully talk about the coefficients of partial determination, the Global F, the model coefficient of determination, and the adjusted model coefficient of determination;

Models in which we have at least one continuous independent variable and at least one discrete independent variable are called "Analysis of Covariance" (ANCOVA) models. Here, too, we can still meaningfully talk about the coefficients of partial determination, the Global F, the model coefficient of determination, and the adjusted model coefficient of determination;

Multivariable models allow us to begin to address issues of causality. Although being able to predict the value of the dependent variable is often thought of as the primary rationale for the various general linear model forms (analysis of variance, regression, analysis of covariance), the issue of cause is also frequently of interest;

A confounding model is one of the basic forms of causal models. Confounding models allow for better decisions to be made for resource allocation.

ANACOVA Review: KHI (1)

```
KHI.dat <- read.table("KHI.dat", header=TRUE,
  sep="", na.strings="NA", dec=".", strip.white=TRUE)
summary(KHI.dat)
```

```
Oneway <- lm(SAT~PropType,data=KHI.dat)
summary(Oneway)
etasq(Oneway,anova=TRUE, partial=FALSE)
```

```
       ID              PropType         Age              SAT
 Min.   : 104123   1-Class:70   Min.   :20.00   Min.   :38.00
 1st Qu.:2470562   2-Premi:72   1st Qu.:32.00   1st Qu.:46.00
 Median :5353738   3-Luxur:83   Median :39.00   Median :50.00
 Mean   :5159247                Mean   :39.04   Mean   :50.02
 3rd Qu.:7621615                3rd Qu.:46.00   3rd Qu.:54.00
 Max.   :9935214                Max.   :59.00   Max.   :62.00
```

<u>Unconditional</u> effect

Property Type → Satisfaction

```
Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)     47.3857     0.5440  87.112  < 2e-16 ***
PropType2-Premi  5.3365     0.7639   6.986 3.26e-11 ***
PropType3-Luxur  2.5179     0.7385   3.409 0.000774 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.551 on 222 degrees of freedom
Multiple R-squared:  0.1805,    Adjusted R-squared:  0.1731
F-statistic: 24.44 on 2 and 222 DF,  p-value: 2.543e-10
```

```
Response: SAT
            eta^2 Sum Sq  Df F value    Pr(>F)
PropType  0.18048 1012.6   2  24.444 2.543e-10 ***
Residuals         4598.3 222
```

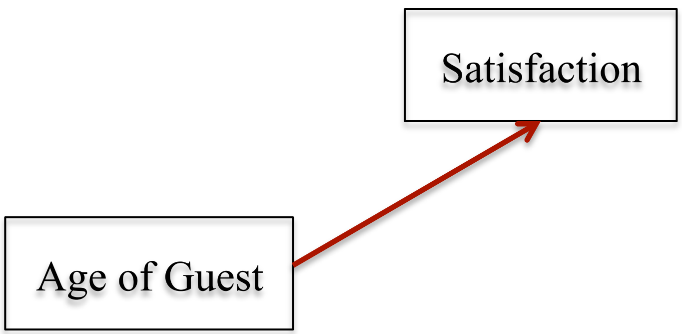
ANACOVA Review: KHI (2)

```
SLR<-lm(SAT~Age,data=KHI.dat)
summary(SLR)
etasq(SLR,anova=TRUE, partial=FALSE)
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 39.10887    1.24676  31.368   <2e-16 ***
Age          0.27954    0.03108   8.994   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.297 on 223 degrees of freedom
Multiple R-squared:  0.2662,    Adjusted R-squared:  0.2629
F-statistic: 80.89 on 1 and 223 DF,  p-value: < 2.2e-16
```

Unconditional effect

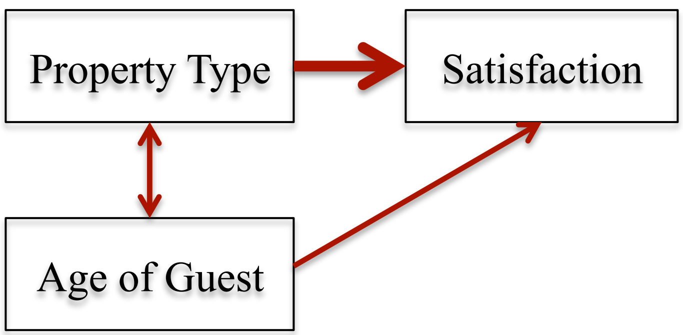



```
Response: SAT
           eta^2 Sum Sq  Df F value    Pr(>F)
Age      0.26619 1493.5   1  80.892 < 2.2e-16 ***
Residuals        4117.3 223
```

ANACOVA Review: KHI (3)

```
ANACOVA <- lm(SAT~PropType + Age,data=KHI.dat)
summary(ANACOVA)
etasq(ANACOVA, anova=TRUE, partial=FALSE)
library(lsmeans)
lsmeans(ANACOVA,"PropType")
```

<u>Conditional</u> effect




```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     39.19738    1.69126  23.176  < 2e-16 ***
PropType2-Premi  0.14095    1.25271   0.113    0.911
PropType3-Luxur  0.14224    0.84197   0.169    0.866
Age              0.27478    0.05405   5.084 7.88e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.316 on 221 degrees of freedom
Multiple R-squared:  0.2663,	Adjusted R-squared:  0.2563
F-statistic: 26.74 on 3 and 221 DF,  p-value: 8.601e-15
```

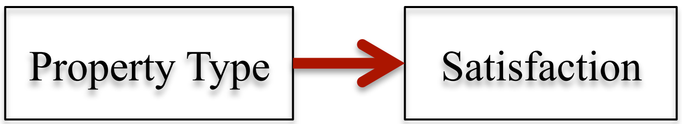
```
Response: SAT
             eta^2 Sum Sq  Df F value     Pr(>F)
PropType  0.000116    0.5   2  0.0143     0.9858
Age       0.104689  481.4   1 25.8450 7.878e-07 ***
Residuals          4116.8 221
```

```
PropType lsmean    SE  df lower.CL upper.CL
1-Class    49.9 0.718 221     48.5     51.3
2-Premi    50.1 0.729 221     48.6     51.5
3-Luxur    50.1 0.475 221     49.1     51.0
```

ANACOVA Review: KHI (4)

```
Oneway <- lm(SAT~PropType,data=KHI.dat)
summary(Oneway)
etasq(Oneway,anova=TRUE, partial=FALSE)
```

Unconditional effect



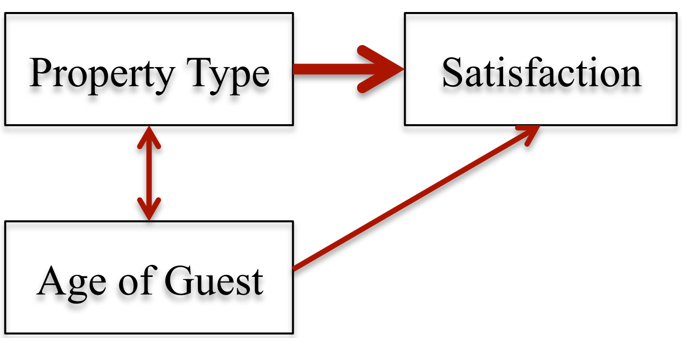

```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      47.3857     0.5440  87.112  < 2e-16 ***
PropType2-Premi   5.3365     0.7639   6.986 3.26e-11 ***
PropType3-Luxur   2.5179     0.7385   3.409 0.000774 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.551 on 222 degrees of freedom
Multiple R-squared:  0.1805,    Adjusted R-squared:  0.1731
F-statistic: 24.44 on 2 and 222 DF,  p-value: 2.543e-10
```

```
Response: SAT
            eta^2 Sum Sq  Df F value    Pr(>F)
PropType  0.18048 1012.6   2  24.444 2.543e-10 ***
Residuals         4598.3 222
```

```
ANACOVA <- lm(SAT~PropType + Age,data=KHI.dat)
summary(ANACOVA)
etasq(ANACOVA, anova=TRUE, partial=FALSE)
library(lsmeans)
lsmeans(ANACOVA,"PropType")
```

Conditional effect




```
Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     39.19738    1.69126  23.176  < 2e-16 ***
PropType2-Premi  0.14095    1.25271   0.113    0.911
PropType3-Luxur  0.14224    0.84197   0.169    0.866
Age              0.27478    0.05405   5.084 7.88e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.316 on 221 degrees of freedom
Multiple R-squared:  0.2663,    Adjusted R-squared:  0.2563
F-statistic: 26.74 on 3 and 221 DF,  p-value: 8.601e-15
```

```
Response: SAT
             eta^2 Sum Sq  Df F value    Pr(>F)
PropType  0.000116    0.5   2  0.0143    0.9858
Age       0.104689  481.4   1 25.8450 7.878e-07 ***
Residuals          4116.8 221
```

Quiz 4

A dataset named Quiz4.Dat has three variables: a continuous variable Y (the dependent variable) and two discrete variables, X1 (categories: “A” and “B”) and X2 (categories: “P”, “Q”, and “R”). You conduct two one-way ANOVAs (one for X1 and one for X2) and a two-way ANOVA, producing the following output:

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  14.9167     0.2759  54.075   <2e-16 ***
X1B           0.5000     0.3901   1.282    0.201    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.022 on 238 degrees of freedom
Multiple R-squared:  0.006855,	Adjusted R-squared:  0.002682 
F-statistic: 1.643 on 1 and 238 DF,  p-value: 0.2012
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  15.7500     0.3363  46.827   <2e-16 ***
X2Q          -0.7500     0.4757  -1.577   0.1162    
X2R          -1.0000     0.4757  -2.102   0.0366 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.008 on 237 degrees of freedom
Multiple R-squared:  0.0198,	Adjusted R-squared:  0.01153 
F-statistic: 2.394 on 2 and 237 DF,  p-value: 0.09347
```

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  15.4891     0.3662  42.301   <2e-16 ***
X1B           0.6957     0.3950   1.761   0.0795 .  
X2Q          -0.8370     0.4761  -1.758   0.0801 .  
X2R          -1.1739     0.4838  -2.427   0.0160 *  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 2.995 on 236 degrees of freedom
Multiple R-squared:  0.03252,	Adjusted R-squared:  0.02022 
F-statistic: 2.644 on 3 and 236 DF,  p-value: 0.04992
```

```
             eta^2  Sum Sq  Df F value  Pr(>F)  
X1        0.012642   27.83   1  3.1018 0.07950 .
X2        0.025514   56.16   2  3.1301 0.04553 *
Residuals          2117.11 236                  
```

Quiz 4

Please answer the following questions. ***NOTE: If any part of your answer involves a p-value, include that value as part of your answer.***

1. What can we conclude about the mean value of Y across all categories of X1 (without controlling for X2)? . How did you reach that conclusion?

2. What can we conclude about the mean value of Y across all categories of X2 (without controlling for X1)? . How did you reach that conclusion?

3. What can we conclude about the mean value of Y across all categories of X1 (after controlling for X2)? . How did you reach that conclusion?

4. What can we conclude about the mean value of Y across all categories of X2 (after controlling for X1)? . How did you reach that conclusion?

5. What is our best estimate of the proportion of variation in Y in the population that is predictable collectively by X1 and X2? (accurate to 4 places to the right of the decimal point)

Prelude to Today's Discussion

In our recent sessions, we have been focusing on questions involving means and slopes.

Today, we will be taking up questions involving proportions and counts.

We will also take a closer look at the null and alternative hypothesis – and what conclusions you can (and cannot) legitimately draw about the population.

Reviewing the "Statistical Significance" Question: The Null Hypothesis and The Alternative Hypothesis

Population Regression Equation:	$Y = \beta_0 + \beta_1 * X + \varepsilon$
Sample Regression Equation:	$Y = b_0 + b_1 * X + e$
Null Hypothesis (H_0):	$\beta_1 = 0$ The best-fitting regression line in the population has a slope of zero
Alternative Hypothesis (H_A):	$\beta_1 \neq 0$ The best-fitting regression line in the population has a non-zero slope
Relevant statistical theory:	Statistical theory states that, given certain assumptions, when H_0 is true, the sampling distribution of the slope will be approximately normally distributed, with estimatable mean and standard error. This allows us to estimate seeing a slope as far from zero (or farther) as the slope from our sample when H_0 is true.
Reject H0:	If our sample slope is unlikely when H_0 is true, H_0 is likely to be false; we reject H_0
Fail to reject H0:	If our sample slope is NOT unlikely when H_0 is true, we FAIL TO reject H_0

A similar logic prevails when focusing on proportions and counts

Inferences About a Population Proportion π (Confidence Interval)

Researchers at Aranos, Inc., have developed a new drug treatment for a specific form of cancer. In a clinical trial, a random sample of 870 patients with this form of cancer was treated with the drug; 330 of them survived at least 5 years after treatment. Aranos is now determining whether or not to go through the costly procedure of obtaining FDA approval and bringing the drug to market. Estimate the proportion of all patients with this type of cancer who will survive at least 5 years, using a 95% confidence interval.

$$\hat{\pi} = \frac{330}{870} = 0.3793103$$

$$\hat{\sigma}_{\hat{\pi}} = \sqrt{\frac{(.38)(1-.38)}{870}} = 0.01645034$$

$$z_{crit} = 1.959964$$

$$CI: 0.3793103 \pm 1.959964 * 0.01645034$$

$$= \{0.3470683, \quad 0.4115524\}$$

```
pi.hat <- 330/870
std.err.pi.hat <- sqrt(pi.hat*(1-pi.hat)/870)
z.crit <- qnorm(1-.05/2)
lb <- pi.hat - z.crit*std.err.pi.hat
ub <- pi.hat + z.crit*std.err.pi.hat
cat ("pi-hat=",pi.hat, ", std. err=",
     std.err.pi.hat, ", critical value of z=",
  z.crit,", 95 CI lower bound=",lb,
  ", 95% CI upper bound=",ub)
```

```
pi-hat= 0.3793103 , std. err= 0.01645034 , critical value of z= 1.959964 ,
95 CI lower bound= 0.3470683 , 95% CI upper bound= 0.4115524
```

Inferences About a Population Proportion π (Hypothesis Test: Directional H_A)

Researchers at Aranos, Inc., have developed a new drug treatment for a specific form of cancer. In a clinical trial, a random sample of 870 patients with this form of cancer was treated with the drug; 330 of them survived at least 5 years after treatment. Aranos is now determining whether or not to go through the costly procedure of obtaining FDA approval and bringing the drug to market. Can we be reasonably sure that <u>more than 35%</u> of the population survives at least 5 years?

$H_0: \pi \le 0.35 \quad H_A: \pi > 0.35$

$$\hat{\pi} = \frac{330}{870} = 0.3793103$$

$$\hat{\sigma}_{\hat{\pi}} = \sqrt{\frac{(.35)(1-.35)}{870}} = 0.01617078$$

$$z_{crit} = \boxed{1.644854}$$

$$z_{calc} = \frac{0.3793103-0.35}{0.01617078} = 1.812549$$

$1.812549 > 1.644854$ ==>Reject H_0, Accept H_A

```
pi.hat <- 330/870
std.err.pi.hat <- sqrt(.35*(1-.35)/870)
z.crit <- qnorm(1-.05)
z.calc <- (pi.hat - .35)/std.err.pi.hat
cat ("pi-hat=",pi.hat, ", std. err=",
     std.err.pi.hat, ", critical value of z=",
     z.crit,", z.calc=", z.calc)
```

```
pi-hat= 0.3793103 , std. err= 0.01617078 , critical value of z= 1.644854 , z.calc= 1.812549
```

Inferences About a Population Proportion π (Hypothesis Test: Non-Directional H_A)

Researchers at Aranos, Inc., have developed a new drug treatment for a specific form of cancer. In a clinical trial, a random sample of 870 patients with this form of cancer was treated with the drug; 330 of them survived at least 5 years after treatment. Aranos is now determining whether or not to go through the costly procedure of obtaining FDA approval and bringing the drug to market. Can we be reasonably sure that <u>either less than or more than 35%</u> of the population survives at least 5 years?

$H_0: \pi = 0.35 \quad H_A: \pi \neq 0.35$

$$\hat{\pi} = \frac{330}{870} = 0.3793103$$

$$\hat{\sigma}_{\hat{\pi}} = \sqrt{\frac{(.35)(1-.35)}{870}} = 0.01617078$$

$$z_{crit} = \boxed{1.959964}$$

$$z_{calc} = \frac{0.3793103\text{-}0.35}{0.01617078} = 1.812549$$

1.812549<1.959964 ==>*Fail* to reject H_0, *Fail* to Accept H_A

```
pi.hat <- 330/870
std.err.pi.hat <- sqrt(.35*(1-.35)/870)
z.crit <- qnorm(1-.05/2)
z.calc <- (pi.hat - .35)/std.err.pi.hat
cat ("pi-hat=",pi.hat, ", std. err=",
     std.err.pi.hat, ", critical value of z=",
     z.crit,", z.calc=", z.calc)
```

```
pi-hat= 0.3793103 , std. err= 0.01617078 , critical value of z= 1.959964 , z.calc= 1.812549
```

Inferences About the Difference in Two Population Proportions $\pi_1 - \pi_2$ (Confidence Interval)

Illiad, Inc., a manufacturer of laptop computers, gets the batteries for the computers it sells from two suppliers: Acme Systems, Inc., and Bartelt, Inc. Illiad wishes to move to a single supplier, and will base its decision in part on the percentage of defective batteries supplied by each of the two. Among a random sample of 350 batteries supplied by Acme, 35 were defective. Among a random sample of 250 batteries supplied by Bartelt, 20 were defective. Estimate the difference in the proportion of defective batteries provided by these two suppliers, including a 95% confidence interval.

$$\hat{\pi}_1 = \frac{35}{350} = .10,\ \hat{\pi}_2 = \frac{20}{250} = .08,\ \ \hat{\pi}_1 - \hat{\pi}_2 = .02$$

$$\hat{\sigma}_{\hat{\pi}_1 - \hat{\pi}_2} = \sqrt{\frac{(.10)(1-.10)}{350} + \frac{(.08)(1-.08)}{250}} = 0.02348495$$

$$z_{crit} = 1.959964$$

$$CI: .02 \pm 1.959964 * 0.02348495$$

$$= \{-0.02602966,\quad 0.06602966\}$$

```
pi.hat1 <- 35/350
pi.hat2 <- 20/250
pi.hat.diff <- pi.hat1 - pi.hat2
std.err.pi.hat.diff <- sqrt(pi.hat1*(1-pi.hat1)/350+pi.hat2*(1-pi.hat2)/250)
z.crit <- qnorm(1-.05/2)
lb <- pi.hat.diff - z.crit*std.err.pi.hat.diff
ub <- pi.hat.diff + z.crit*std.err.pi.hat.diff
cat ("pi-hat diff=",pi.hat.diff, ", std. err=",
     std.err.pi.hat.diff, ", critical value of z=",
     z.crit,", 95 CI lower bound=",lb,
     ", 95% CI upper bound=",ub)
```

The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Inferences About the Difference in Two Population Proportions $\pi_1 - \pi_2$ (Hypothesis Test: Directional H_A)

Illiad, Inc., a manufacturer of laptop computers, gets the batteries for the computers it sells from two suppliers: Acme Systems, Inc., and Bartelt, Inc. Illiad wishes to move to a single supplier, and will base its decision in part on the percentage of defective batteries supplied by each of the two. Among a random sample of 350 batteries supplied by Acme, 35 were defective. Among a random sample of 250 batteries supplied by Bartelt, 20 were defective. Can we be reasonably certain that the proportion of Acme defective batteries exceed the proportion of Bartelt defective batteries?

$$H_0: \pi_1 \leq \pi_2 \quad H_A: \pi_1 > \pi_2$$

$$\hat{\pi}_1 = \frac{35}{350} = .10, \ \hat{\pi}_2 = \frac{20}{250} = .08, \ \hat{\pi}_1 - \hat{\pi}_2 = .02$$

$$\hat{\sigma}_{\hat{\pi}_1 - \hat{\pi}_2} = \sqrt{\frac{(.10)(1-.10)}{350} + \frac{(.08)(1-.08)}{250}} = 0.02348495$$

$$z_{crit} = 1.644854$$

$$z_{calc} = \frac{.02}{0.02348495} = 0.8516092$$

$0.8516092 < 1.644854$ ==> *Fail* to reject H_0, *Fail* to Accept H_A

```
pi.hat1 <- 35/350
pi.hat2 <- 20/250
pi.hat.diff <- pi.hat1 - pi.hat2
std.err.pi.hat.diff <- sqrt(pi.hat1*(1-pi.hat1)/350+pi.hat2*(1-pi.hat2)/250)
z.crit <- qnorm(1-.05)
z.calc <- (pi.hat1-pi.hat2)/std.err.pi.hat.diff
cat ("pi-hat diff=",pi.hat.diff, ", std. err=",
     std.err.pi.hat.diff, ", critical value of z=",
     z.crit,", z.calc=",z.calc)
```

```
pi-hat diff= 0.02 , std. err= 0.02348495 , critical value of z= 1.644854 , z.calc= 0.8516092
```

Inferences About the Difference in Two Population Proportions $\pi_1 - \pi_2$ (Hypothesis Test: Non-Directional H_A)

Illiad, Inc., a manufacturer of laptop computers, gets the batteries for the computers it sells from two suppliers: Acme Systems, Inc., and Bartelt, Inc. Illiad wishes to move to a single supplier, and will base its decision in part on the percentage of defective batteries supplied by each of the two. Among a random sample of 350 batteries supplied by Acme, 35 were defective. Among a random sample of 250 batteries supplied by Bartelt, 20 were defective. Can we be reasonably certain that the two population proportions differ?

$$H_0: \pi_1 = \pi_2 \quad H_A: \pi_1 \neq \pi_2$$

$$\hat{\pi}_1 = \frac{35}{350} = .10, \ \hat{\pi}_2 = \frac{20}{250} = .08, \ \hat{\pi}_1 - \hat{\pi}_2 = .02$$

$$\hat{\sigma}_{\hat{\pi}_1 - \hat{\pi}_2} = \sqrt{\frac{(.10)(1-.10)}{350} + \frac{(.08)(1-.08)}{250}} = 0.02348495$$

$$z_{crit} = 1.959964$$

$$z_{alc} = \frac{.02}{0.02348495} = 0.8516092$$

$0.8516092 < 1.959964 \implies$ *Fail* to reject H_0, *Fail* to Accept H_A

```
pi.hat1 <- 35/350
pi.hat2 <- 20/250
pi.hat.diff <- pi.hat1 - pi.hat2
std.err.pi.hat.diff <- sqrt(pi.hat1*(1-pi.hat1)/350+pi.hat2*(1-pi.hat2)/250)
z.crit <- qnorm(1-.05/2)
z.calc <- (pi.hat1-pi.hat2)/std.err.pi.hat.diff
cat ("pi-hat diff=",pi.hat.diff, ", std. err=",
     std.err.pi.hat.diff, ", critical value of z=",
     z.crit,", z.calc=",z.calc)
```

```
pi-hat diff= 0.02 , std. err= 0.02348495 , critical value of z= 1.959964 , z.calc= 0.8516092
```

Inferences About the Difference in Two Population Proportions $\pi_1 - \pi_2$ When the Data are Paired

Your firm distributes romaine lettuce. There has recently been a recall of romaine lettuce that was distributed by a competitor. You create an advertisement that you think will convince people to purchase your lettuce, but you want to test it out to see if you are correct. You randomly select 400 people and ask them if they will or will not purchase your lettuce (Pretest). You then show them the advertisement, and ask again (Posttest). You use the McNemar test to determine whether there has been a change in the percentage of people who will purchase your product.

$$H_0: \pi_{pretest} = \pi_{posttest} \quad H_A: \pi_{pretest} \neq \pi_{posttest}$$

```
Purchase <-
  matrix(c(200,38,62,100),
         nrow = 2,
         dimnames = list("Pretest" = c("Yes", "No"),
                         "Posttest" = c("Yes", "No")))
Purchase
mcnemar.test(Purchase)
```

```
        Posttest
Pretest Yes  No
    Yes 200  62
    No   38 100
```

```
        McNemar's Chi-squared test with continuity correction

data:  Purchase
McNemar's chi-squared = 5.29, df = 1, p-value = 0.02145
```

Focus: H_0 or H_A?

H_0: The two suppliers have equal proportions of defective batteries
H_A: The two suppliers do not have equal proportions of defective batteries (i.e., a non-directional alternative hypothesis).

- If you have chosen to focus on H_A, you have only two options:
  (1) You can be at least 95% confident that one supplier has a different proportion of defective batteries than the other, or
  (2) You cannot be at least 95% confident that one supplier has a different proportion of defective batteries than the other.

- If you have chosen to focus on H_0, you get yourself into a more complicated (but exactly equivalent) pair of options:
  (1) You can be at least 95% confident that it is untrue that the two suppliers have equal proportions of defective batteries., or
  (2) You cannot be at least 95% confident that it is untrue that the two suppliers have equal proportions of defective batteries.

Which Statements Are Defensible?

Consider the following attempts, all drawn from prior classes, to express in words the concept of "failing to reject the null hypothesis." Which ones are defensible?

1. **"I can be 95% confident that one supplier has a different proportion of defective batteries than the other"**
2. **"I can be 95% confident that the two suppliers have equal proportions of defective batteries"**
3. **"I can be 95% confident that neither supplier has a higher proportion of defective batteries than the other"**
4. **"The data are insufficient to allow me to say anything about the comparative proportions of defective batteries supplied by the two suppliers"**
5. **"I cannot be 95% confident that one supplier has a different proportion of defective batteries than the other"**
6. **"I cannot be 95% confident that the two suppliers have equal proportions of defective batteries"**
7. **"I can, with 95% confidence, fail to reject the null hypothesis"**
8. **"I can fail to (reject the null hypothesis with 95% confidence)"**
9. **"I can (fail to reject the null hypothesis) with 95% confidence"**
10. **"I can fail to reject the null hypothesis with 95% confidence"**

Key Points in Today's Discussion

Inferential statistics consists of two subdomains: estimation and hypothesis testing;

The estimation subdomain consists of point estimation and interval estimation

While interval estimation can, in some cases, be used to test a hypothesis, this is not generally a good practice – especially in the context of directional alternative hypotheses

We learned how to calculate a confidence interval for a single population proportion and for the difference in two population proportions

We learned how to test a hypothesis about a population proportion (both non-directional and directional) and about a difference in two population proportions

The advantage of focusing on the alternative hypothesis when summarizing the results of a statistical test

Which types of statements are (and are NOT) defensible in reaching a conclusion about a statistical test

Reminders

- **Assignment 5, the last assignment, will be available tonight st 7:00pm tonight and will be due at 4:25pm next Wednesday (via Blackboard).**

- **Optional quiz as usual: Tuesday, 8:30am.**

<u>HAVE A GREAT WEEK</u>!