

BIOS 600.001 Final Exam

December 11, 2012

Honor Statement. I pledge that I have not used any reference materials (including electronic materials) during this examination. I pledge that I have neither given nor received any aid from any other person during this examination, and that the work presented here is entirely my own. I furthermore pledge that I will not reveal any of the material on this examination, either in the form of the exact question or the topics covered, to any person for any reason until the end of fall term. I pledge that I will report all Honor Code violations observed by me. I understand that if I have committed any of the above, I have violated the UNC Honor Code.

Name: _____

Signature: _____

Date: _____

INSTRUCTIONS: No electronic devices are permitted. Full credit will be given for correct answers that are unsimplified, e.g. $1 + 2(3) + 4(5)$ is an acceptable form. There are 100 points on this exam not counting the bonus. Please ask if you have any questions. Note that this exam will be videorecorded.

EXAMS ARE DUE AT 10:45. At 10:45am you should be signing the honor statement and turning in the exam. Exams turned in after 10:45 am will be penalized one point for the first minute delay (10:46) and 5 points per minute thereafter (starting at 10:47).

1. (15 points total) Researchers are designing a study with $\alpha = 0.05$ and power $1 - \beta = 0.80$. Compute the following conditional probabilities concerning the outcomes of this future study. If it is not possible to compute the probability, explain what additional information is needed.

(a) (3 points) $Pr(\text{Do not reject } H_0 \mid H_0 \text{ true})$

(b) (3 points) $Pr(\text{Reject } H_0 \mid H_0 \text{ true})$

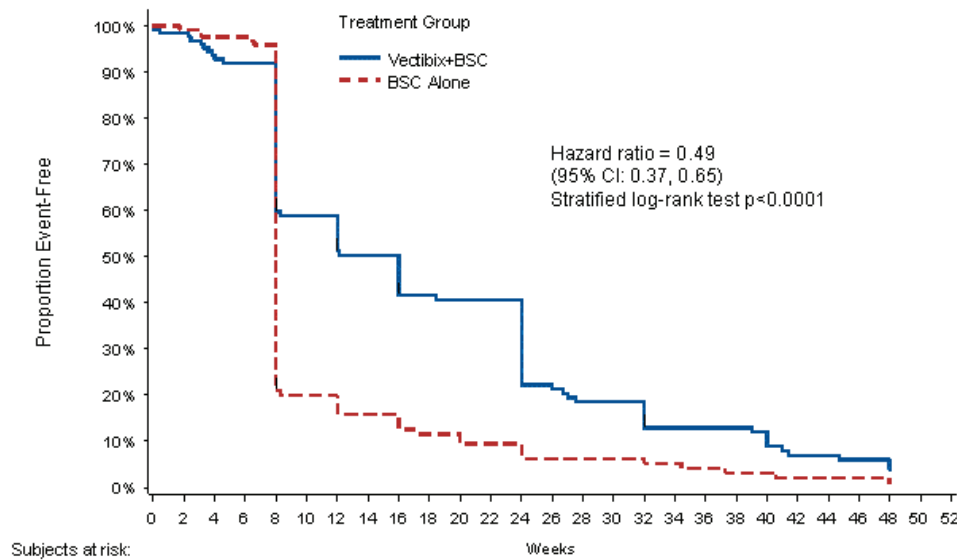
(c) (3 points) $Pr(\text{Do not reject } H_0 \mid H_0 \text{ false})$

(d) (3 points) $Pr(\text{Reject } H_0 \mid H_0 \text{ false})$

(e) (3 points) $Pr(H_0 \text{ false} \mid \text{Reject } H_0)$

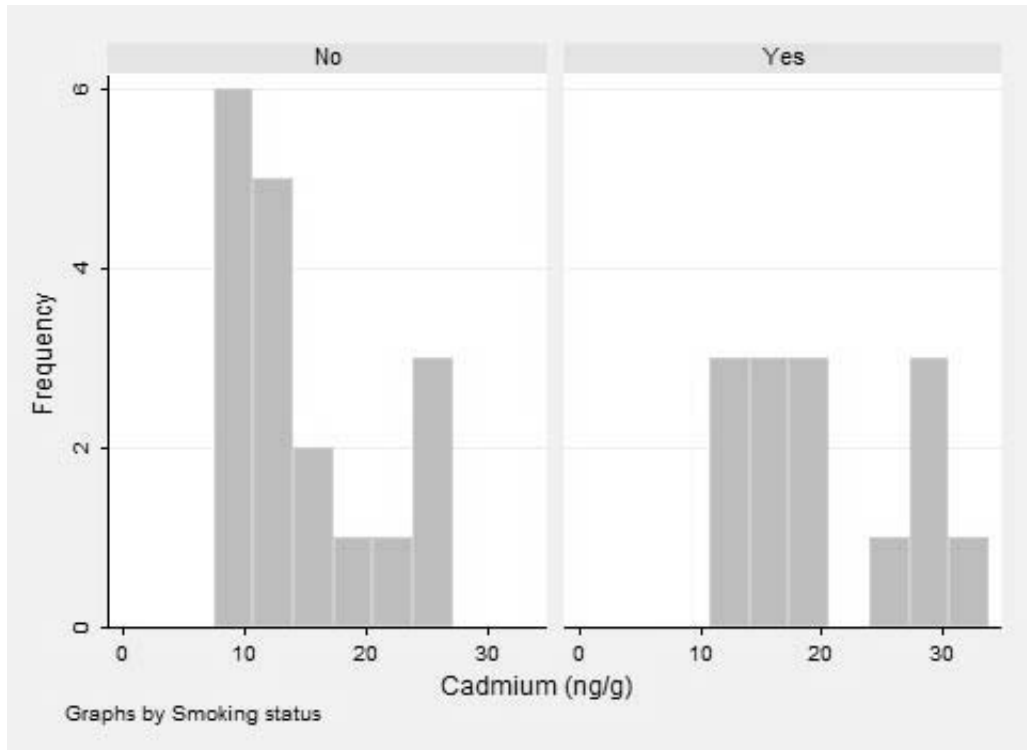
2. (12 points) A researcher is interested in the potential association between artificial colorings in foods and child hyperactivity. A group of children will be randomized in a 1:1 ratio to receive either a typical American diet or a diet free of all artificial food colorings. After the study period, hyperactivity response will be measured on a continuous scale. The power calculation indicates that a sample size of 350 is sufficient to detect a difference of 0.3 standard deviations in the hyperactivity level between the two groups, assuming a type I error rate of 5% and 80% power for a two-sided hypothesis test.
- (a) (4 points) Researchers want to increase the power to 90%. How will increasing the power affect the required sample size if the other factors remain fixed?
- (b) (4 points) Researchers decide instead they would like to detect a difference of 0.5 standard deviations. How will changing this minimum detectable difference affect the power if the other factors remain fixed?
- (c) (4 points) The investigators get a new grant and can increase the sample size to 500. How will this affect the power if the other factors remain fixed?

3. (12 points) A randomized, controlled trial was conducted to evaluate a new treatment (Vectibix) and best supportive care (BSC) for colorectal cancer versus BSC alone. The Kaplan-Meier plot and result of a log-rank test are provided below. The outcome of the study was the event of death or disease progression, so the desired outcome for a patient is to remain event-free.



- (a) (6 points) What are the estimated median survival times in each of the 2 groups?
- (b) (6 points) Which treatment is superior: Vectibix+BSC, BSC alone, or neither? Explain your answer.

4. (14 points total) In a study of factors thought to be responsible for adverse effects of smoking on human reproduction, cadmium level determinations (ng/g) were made on placental tissue of a sample of 14 smoking mothers (smoking status=yes) and an independent random sample of 18 nonsmoking mothers (smoking status=no). The data are summarized in the figure below.



- (a) (2 points) Approximately what is the median cadmium level in placental tissue of nonsmokers?
- (b) (2 points) Approximately what is the 75th %ile of cadmium levels in placental tissue of smokers?

(c) (*5 points*) Which statistical test is most appropriate for evaluating whether cadmium levels were different on placentas from smoking and nonsmoking mothers? Explain your choice and provide the null and alternative hypotheses corresponding to this test.

(d) (*5 points*) Suppose you carry out the test and obtain $p = 0.008$. Provide a short conclusion and explanation of the results suitable for publication in a scientific journal.

5. (15 points total) Researchers used age (in years) and education level (years of schooling) to predict the capacity to direct attention (CDA) in elderly subjects. CDA refers to neural inhibitory mechanisms that focus the mind on what is meaningful, while blocking out distractions. The study collected information on 71 older women with normal mental status. The CDA measurement is continuous, with scores ranging from -7.7 to 9.6 and higher scores corresponding with better attentional functioning.

Researchers fit the linear regression model

$$CDA_i = \beta_0 + \beta_1 age_i + \beta_2 education_i + \varepsilon_i$$

and obtained the following parameter estimates.

Parameter	Estimate	95% CI
β_0	5.5	(-3.2, 14.2)
β_1	-0.2	(-0.3, -0.1)
β_2	0.6	(0.3, 0.8)

- (a) (5 points) Is the association between age and CDA statistically significant, controlling for education? Explain why or why not and describe how one additional year in age is expected to affect the CDA score for a fixed level of education.

(b) (*5 points*) What is the expected CDA score for a woman who is 70 years old and who has 20 years of education?

(c) (*5 points*) Suppose two women both have 20 years of education, but one is 80 years old and the other is 70 years old. Based on the model, how should you expect the 80 year old woman's CDA score to differ from the 70 year old woman's CDA score? Be as specific as possible.

6. (*20 points total*) In 2007, the Finnish National Board of Education and the National Public Health Institute recommended to schools that they quit selling candies and soft drinks. Finnish researchers wished to determine whether the proportion of schools selling candy and soft drinks changed from 2007 to 2008 (after the national recommendation). They provided surveys to all upper comprehensive schools in Finland in 2007 (before the recommendation) and again to the same schools in 2008 (after the recommendation).





(a) (*4 points*) What are H_0 and H_A ?

(b) (*4 points*) Which test should you use to test H_0 ?

- (c) (*4 points*) Among the 150 schools that sold candy and soft drinks in both 2007 and 2008, researchers compared the number of items sold per week in 2007 and 2008 and wished to test whether average sales levels were the same in the two years. What are H_0 and H_A in this setting, and which test should you use to evaluate H_0 ?
- (d) (*4 points*) Suppose the estimated difference in the mean number of items sold per week among the 150 schools who sold candy and soft drinks in both years was 100 items/week, with significantly more items/week sold in 2007 than in 2008 ($p < 0.05$). Which 95% confidence interval for the population mean difference is correct?
- i. (-101.6, -98.4)
 - ii. (98.4, 101.6)
 - iii. (98.4, 103.2)
 - iv. (-98.4, 103.2)
- (e) (*4 points*) Suppose the p-value in (d) above is exactly $p = 0.02$. Provide an appropriate interpretation of this p-value. Specifically, this p-value is the probability of what event?

7. (12 points) The National Audubon Society has sponsored a “Christmas Bird Count” for over 100 years. This event was founded by ornithologist Frank Chapman in 1900 as a new tradition to replace the usual Christmas “Side Hunt,” in which people formed teams to see which one could kill the greatest number of birds and small game animals.

You are testing whether the mean number of birds of four species is the same, corresponding to $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$. Researchers collected the data by counting the number of birds in seven different geographical areas for each species. They averaged the seven counts for each species to obtain \bar{y}_i , $i = 1, 2, 3, 4$, and reported the estimated means and the estimated standard deviations s_i for each species. You will use the ANOVA model $y_{ij} = \mu_i + \varepsilon_{ij}$, $i = 1, 2, 3, 4$, $j = 1, \dots, 7$ to analyze these data.

Species	Parameter	n_i	\bar{y}_i	s_i
Partridges 	μ_1	7	16.44	0.87
Turtle Doves 	μ_2	7	16.51	0.44
French Hens 	μ_3	7	16.07	0.40
Colly Birds 	μ_4	7	14.96	1.07

The F statistic corresponding to the null hypothesis $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$ is 6.45 (3 ndf, 24 ddf) with a corresponding p-value of 0.002.

- (a) (4 points) Do you reject or fail to reject H_0 ? Does the p-value provide evidence of any difference between the groups, or not?

In order to investigate differences between species, the investigators tested differences between each pair of species and have provided the following table.

Parameter	Estimate	95% CI	p-value
$\mu_1 - \mu_2$	-0.07	(-0.89, 0.75)	0.860
$\mu_1 - \mu_3$	0.37	(-0.45, 1.19)	0.363
$\mu_1 - \mu_4$	1.49	(0.67, 2.31)	0.001
$\mu_2 - \mu_3$	0.44	(-0.38, 1.26)	0.280
$\mu_2 - \mu_4$	1.56	(0.74, 2.38)	0.001
$\mu_3 - \mu_4$	1.11	(0.29, 1.93)	0.010

- (b) (4 points) Using this table, describe differences in mean bird counts by species using language suitable for journal publication.

- (c) (4 points) Circle all of the assumptions below that are needed for ANOVA to be valid.

- i. Equal variances of the counts of each bird species.
- ii. Equal counts of each bird species.
- iii. Dependent observations
- iv. Independent observations
- v. Each bird must be capable of laying AN OVA. (OK, technically an ovum for the Latin scholars out there.)
- vi. A NOVA must not take out Earth before you can run the analysis in Stata.

- (d) 5 POINT BONUS: Famed researchers Drs. Donder and Blitzzen wish to test a firmly established historical null hypothesis instead of the null hypothesis $H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$. In particular, the true *status quo* (null hypothesis) is that for every partridge seen, there should be on average two turtle doves, three French hens, and four colly birds. They think the hypothesis test should evaluate this more established null hypothesis. Express the new null hypothesis in terms of the μ_i , $i = 1, 2, 3, 4$.