LPO 8800: Statistical Methods in Education Research
Vanderbilt University
At-Home Final Exam
December 6, 2024

Name: _____

By signing below, I agree to the terms of Vanderbilt University's honor code. I attest that I have not collaborated with, or received any external assistance from other individuals on this at-home exam.

Signature: _____

Instructions: Read each question carefully and provide clear, concise responses in your own document. Be sure to complete every part of every question. Partial credit will be given where appropriate. If you make any assumptions to answer a question, please state those assumptions explicitly. Email your completed exam to sean.corcoran@vanderbilt.edu before 9:00 a.m. on **Saturday December 7**. Good luck!

Question 1 The Stata output below comes from the analysis of a randomized experiment in which some students in New York City were offered a voucher to attend private school ($voucher = 1$) and others were not ($voucher = 0$). After several years, the students were tested. The results below show a t-test for the difference in mean achievement ($post\_ach$) between the voucher recipients and non-voucher recipients. For this problem, some values have been removed from the table. (**25 points**)

```
. ttest post_ach, by(voucher)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      78    22.76923    2.112091    18.65349    18.56352    26.97494
       1 |     122    27.61475    1.833798    20.25496    23.98427    31.24524
---------+--------------------------------------------------------------------
combined |     200      25.725    1.395896    19.74096    22.97235    28.47765
---------+--------------------------------------------------------------------
    diff |
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =
Ho: diff = 0                                     degrees of freedom =

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) =               Pr(|T| > |t|) =               Pr(T > t) =
```

(a) Complete the t-test for the difference in mean achievement for voucher and non-voucher students. In your answer include the following elements: (**10 points**)

- The standard error for the difference in means.
- The t-statistic, degrees of freedom, and p-value for the two-sided hypothesis test.
- The 95% confidence interval for the difference in means.
- Your conclusion for the significance test, using $\alpha = 0.05$.

(b) Carefully provide an interpretation *in words* of what the p-value you found in part (a) represents. (**4 points**)

(c) Consider the difference in mean test scores you found in part (a). Regardless of whether this difference is statistically significant or not, would you say this difference is *practically* or *educationally* significant? Briefly explain how you came to this conclusion. (**4 points**)

(d) Suppose that—instead of running the t-test above—you fit a simple regression in which *post_ach* was the outcome variable and *voucher* was the sole explanatory variable. What would the estimated intercept and slope of this regression be? (**4 points**)

(e) Using the information in part (d) and/or the table above, what would the bivariate correlation between these two variables be, and what is the R^2? (**3 points**)

Question 2. 498 adults—218 males and 280 females—were randomly sampled from the U.S. population and asked a battery of questions about their health and health behaviors. The following table shows the count of each who reported they had not visited a doctor within the past year. Use this information to answer the following questions. (**25 points**)

	Reported 0 doctor visits		
	No	Yes	Total
Male	178	40	218
Female	250	30	280
	428	70	498

(a) Should the two samples being compared in this problem (males and females) be considered independent or dependent samples? Briefly explain your answer. (**4 points**)

(b) Conduct a two-sided significance test for a difference in the population proportion of male and female adults who have not visited a doctor in the past year. Use $\alpha = 0.05$. In your answer, report the null and alternative hypotheses, the standard error of the difference under the null, test statistic, and p-value. (**12 points**)

(c) Carefully provide an interpretation *in words* of what the standard error you found in part (b) represents. (**4 points**)

(d) For tests like the one you conducted in part (b), many researchers report the difference in sample proportions and indicate whether or not the difference is statistically significant. (They may also report a p-value). **True or false**: having reported this information, there would be little added value to also reporting a 95% confidence interval. Explain your answer. (**5 points**)

Question 3. In the United States, elementary and secondary schools are funded by revenues from the local, state, and federal governments. The Stata output below comes from a study of the relationship between revenues per pupil from the federal government (rp_fed) and a measure of state per capita income ($personal\_income\_pc$), both measured in dollars. The unit of observation is a state (n=51, including Washington, D.C.). Use these results to answer the following questions. (**25 points—5 each**)

```
. reg rp_fed personal_income_pc

      Source |       SS           df       MS      Number of obs   =        51
-------------+----------------------------------   F(1, 49)        =      2.59
       Model |  405748.937         1  405748.937   Prob > F        =    0.1142
    Residual |  7686199.84        49  156861.221   R-squared       =    0.0501
-------------+----------------------------------   Adj R-squared   =    0.0308
       Total |  8091948.78        50  161838.976   Root MSE        =    396.06

------------------------------------------------------------------------------
           rp_fed |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+---------------------------------------------------------------
personal_income_pc |   .0125402   .0077971     1.61   0.114    -.0031287     .028209
            _cons |   704.6527   319.9391     2.20   0.032     61.71105    1347.594
------------------------------------------------------------------------------
```

(a) Write down the prediction equation and provide an interpretation (in words) of the estimated intercept and slope coefficients.

(b) Mean federal revenues per pupil in this data is \$1,254. What is the mean value of personal income per capita?

(c) Provide a written interpretation of the standard error of the slope coefficient. What assumption(s), if any, must hold for this standard error calculation to be correct?

(d) **True or false?** The intercept and slope coefficient shown above minimize the Root MSE, given the sample data. (Explain your answer).

(e) Briefly explain why the slope coefficient (alone) is not a good indicator of *effect size* for assessing the practical significance of state income per capita as a predictor of federal revenues per student. What would you look at instead?

Question 4. Your research team plans to conduct a randomized experiment with middle school students in a developing country in which some study participants will be given a laptop computer to use at home for schoolwork while others (in a control group) will not. A total of 100 students will be recruited to participate. At the end of the school year, participants will be tested on their math and language skills. The composite score on the test typically has a mean of 100 and standard deviation of 30. You conducted the power analysis shown below. Use this information to answer the following questions. (**25 points—5 points each**)

```
. power twomeans 100 110, sd(30) knownsds n(100)

Estimated power for a two-sample means test
z test assuming sd1 = sd2 = sd
Ho: m2 = m1  versus  Ha: m2 != m1

Study parameters:

        alpha =    0.0500
            N =       100
  N per group =        50
        delta =   10.0000
           m1 =  100.0000
           m2 =  110.0000
           sd =   30.0000

Estimated power:

        power =    0.3848
```

(a) Carefully provide an interpretation *in words* of the estimated power above.

(b) Briefly explain why an alternative hypothesis (in this case, $\delta = 10$) needs to be specified in order to estimate power. If the alternative were $\delta = 8$, would the power of the test be higher or lower? Explain.

(c) How would the original power change if $\alpha = 0.10$? Briefly explain. (You do not need to do the actual calculation).

(d) What is the smallest (right-tail) difference in means that would lead to a rejection of the null under the current design? Hint: the standard error for the difference in means, assuming known and equal variances and an equal sample size in each group is $\sqrt{2\sigma^2/n}$, where n is the number in each group.

(e) **True or false:** doubling the sample size in the study above to 200 will double the power to 0.7696. Briefly explain your answer.