

Unit 6 – Estimation
Homework #10 (Unit 6 – Estimation, part 2 of 2)

SOLUTIONS

1. Alzheimers' disease has a poorer prognosis when it is diagnosed at a relatively young age. Suppose we want to estimate the age at which the disease was first diagnosed using a 90% confidence interval. Under the assumption that the distribution of age at diagnosis is normal, if the population variance is $\sigma^2=85$, how large a sample size is required if we want a confidence interval that is 10 years wide?

Answer: n=10

Solution:

Recall: The 90% confidence interval is given by $\bar{X} \pm (z_{.95})SE(\bar{X})$, \rightarrow

Confidence interval width = [upper limit of CI] - [lower limit of CI]

$$= [\bar{X} + (z_{.95})SE(\bar{X})] - [\bar{X} - (z_{.95})SE(\bar{X})]$$

$$= \bar{X} + (z_{.95})SE(\bar{X}) - \bar{X} + (z_{.95})SE(\bar{X})$$

$$= (2)(z_{.95})SE(\bar{X})$$

$$= (2)(z_{.95}) \frac{\sigma}{\sqrt{n}}$$

Setting confidence interval width on the left hand side to width = 10 allows us to write

$$10 = (2)(z_{.95}) \frac{\sigma}{\sqrt{n}} \rightarrow$$

$$5 = (z_{.95}) \frac{\sigma}{\sqrt{n}} \rightarrow$$

$$\sqrt{n} = \left[\frac{(z_{.95})\sigma}{5} \right] \rightarrow$$

$$n = \left[\frac{(z_{.95})\sigma}{5} \right]^2 \rightarrow$$

$$n = \left[\frac{(1.645)^2(85)}{25} \right] = 9.2005$$

Rounding up yields the required sample size of 10.

2. The National Health and Nutrition Examination Survey of 1975-1980 give the following data on serum cholesterol levels in US males.

Group	Age, years	Population Mean, μ	Population Standard Deviation, σ
1	20-24	180	43
2	25-34	199	49

Suppose the distribution of serum cholesterol is normal in each age group. If you draw simple random samples of size 50 from each of the two groups, what is the probability that the difference between the two sample means (Group 2 mean – Group 1 mean) will be more than 25?

Answer: .257

Solution:

On page 31 of the lecture notes, at the bottom of the page, we learn that

$(\bar{X}_2 - \bar{X}_1)$ is distributed Normal[$(\mu_2 - \mu_1), (\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2})$]

Let \bar{X}_1 = Average among age 20-24. It is distributed Normal($\mu_1=180, \sigma_{\bar{X}_1}^2 = \frac{\sigma_1^2}{n_1} = \frac{43^2}{50}$)

\bar{X}_2 = Average among age 25-34. It is distributed Normal($\mu_1=199, \sigma_{\bar{X}_2}^2 = \frac{\sigma_2^2}{n_2} = \frac{49^2}{50}$)

Thus, $Y=(\bar{X}_2 - \bar{X}_1)$. is distributed Normal with

$$\mu_Y = (\mu_{\bar{X}_2} - \mu_{\bar{X}_1}) = 19$$

$$\sigma_Y^2 = \left[\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2} \right] = \left[\frac{43^2}{50} + \frac{49^2}{50} \right] = 85$$

Now we use the z-score method that we learned in Unit 5, Normal Distribution, and in particular the z-score standardization that is found on page 19 under “(3)”, we have that

Probability group 2 mean – group 1 mean will be more than 25

$$= \Pr[Y > 25]$$

$$= \Pr \left[\frac{Y - \mu_Y}{\sigma_Y} > \frac{25 - 19}{9.2195} \right]$$

$$= \Pr[\text{Normal}(0,1) > 0.65] = \underline{\underline{.257}}$$

- 3 The objectives of a study by Kennedy and Bhambhani (1991) were to use physiological measurements to determine the test-retest reliability of the Baltimore Therapeutic Equipment Work Simulator during three simulated tasks performed at light, medium, and heavy work intensities, and to examine the criterion validity of these tasks by comparing them to real tasks performed in a controlled laboratory setting. Subjects were 30 healthy men between the ages of 18 and 35. The investigators reported a standard deviation of $s=0.57$ for the variable peak oxygen consumption (l/min) during one of the procedures. Assuming normality, compute a 95% confidence interval for the population variance for the oxygen consumption variable.

Answer: (.21, .59)

Solution:

$$(n-1) = 29 \quad S^2 = 0.57^2 \quad \chi^2_{1-\alpha/2} = \chi^2_{.975; DF=29} = 45.722 \quad \chi^2_{\alpha/2} = \chi^2_{.025; DF=29} = 16.047$$

$$\text{Lower limit} = \frac{(n-1)S^2}{\chi^2_{1-\alpha/2; df=(n-1)}} = \frac{(29)(0.57^2)}{45.722} = .2061$$

$$\text{Upper limit} = \frac{(n-1)S^2}{\chi^2_{\alpha/2; df=(n-1)}} = \frac{(29)(0.57^2)}{16.047} = .5872$$

4. The purpose of an investigation by Alahuhta et al (1991) was to evaluate the influence of extradural block for elective caesarian section simultaneously on several maternal and fetal hemodynamic variables and to determine if the block modified fetal myocardial function. The study subjects were eight healthy parturient in gestational weeks 38-42 with uncomplicated singleton pregnancies undergoing elective caesarian section under extradural anesthesia. Among the measurements taken, were maternal diastolic arterial pressure during two stages of the study. The following are the lowest values of this variable at the two stages. Compute a 95% confidence interval for the difference in diastolic blood pressure between the two stages.

Patient ID	1	2	3	4	5	6	7	8
Stage 1	70	87	72	70	73	66	63	57
Stage 2	79	87	73	77	80	64	64	60

Answer: (-0.06, +6.6)

Solution:

Because two measurements are made on each patient, at stages 1 and 2, these data fit the definition of “paired”. The analysis focuses on the differences, per the table below:

Patient ID, i	1	2	3	4	5	6	7	8
$d_i = \text{Stage 2-1}$	9	0	1	7	7	-2	1	3

The actual calculations required to complete the solution are similar to the example on pp 42-44 of the unit 6 notes. For this exercise, we have

$$\bar{d}=3.25 \quad S_d^2 = 15.643 \quad S_d = 3.9551 \quad SE(\bar{d}) = \frac{S_d}{\sqrt{n}} = \frac{3.9551}{\sqrt{8}} = 1.3983$$

$$df=(n-1)=7 \quad t_{1-\alpha/2;df} = t_{.975;7} = 2.365$$

$$\begin{aligned} 95\% \text{ CI for } \mu_d &= \bar{d} \pm (t_{.975;DF=7}) SE(\bar{d}) \\ &= (3.25) \pm (2.365)(1.3983) = (-0.057, 6.557) \end{aligned}$$

5. A possible environmental determinant of lung function in children is the amount of cigarette smoking in the home. To study this question, two groups of children were studied. Group 1 consisted of 23 nonsmoking children aged 5-9 both of whose parents smoke in the home. Group 2 consisted of 20 nonsmoking children aged 5-9 neither of whose parents smoke. The sample mean (sample SD) of FEV1 for group 1 is 2.1 L (0.7) and for the Group 2 children, the sample mean (sample SD) of FEV1 is 2.3 L (0.4). Under the assumption of normality, construct a 95% confidence interval for the ratio of the variance of the two groups. What is your conclusion regarding the reasonableness of the assumption of equality of variances?

Answer: (1.24, 7.37)

Solution:

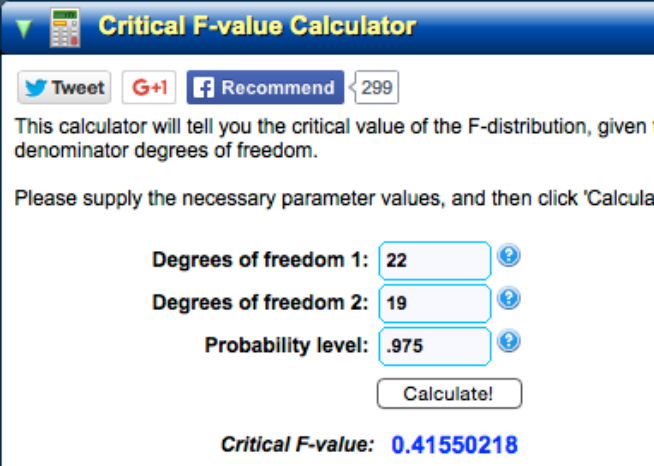
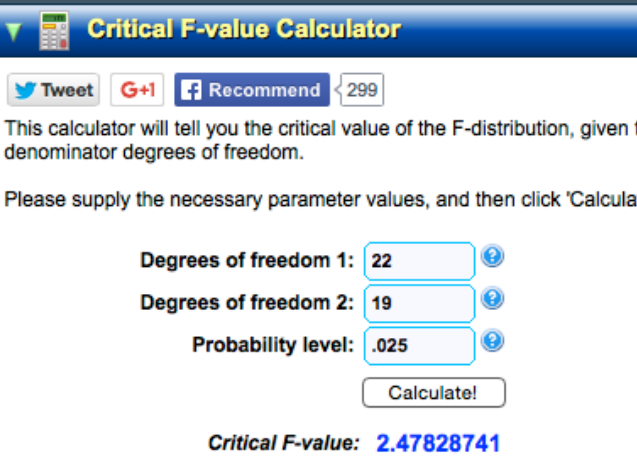
Use the F-distribution calculator from the Daniel Soper site:

<http://www.danielsoper.com/statcalc3/calc.aspx?id=4>

Remember – this calculator provides **RIGHT tail areas only**. Therefore, the 2.5th and 97.5th percentiles are obtained as follows when using this site.

$$S_1^2 = 0.7^2 \quad (n_1 - 1) = (23 - 1) = 22$$

$$S_2^2 = 0.4^2 \quad (n_2 - 1) = (20 - 1) = 19$$

Solution for 2.5 th percentile of F-distribution Numerator df=22 and denominator df=19	Solution for 97.5 th percentile of F-distribution Numerator df=22 and denominator df=19
	
The area to the RIGHT of the 2.5 th percentile is 1 - .025 = .975 →	The area to the RIGHT of the 97.5 th percentile is 1 - .975 = .025 →
$F_{n_1-1, n_2-1; \alpha/2} = F_{22, 19; .025} = 0.4155$	$F_{n_1-1, n_2-1; 1-\alpha/2} = F_{22, 19; .975} = 2.4783$

$$\text{Lower limit} = \left(\frac{1}{F_{n_1-1, n_2-1; (1-\alpha/2)}} \right) \left[\frac{S_1^2}{S_2^2} \right] = \left(\frac{1}{2.4783} \right) \left[\frac{0.7^2}{0.4^2} \right] = 1.2357$$

$$\text{Upper limit} = \left(\frac{1}{F_{n_1-1, n_2-1; \alpha/2}} \right) \left[\frac{S_1^2}{S_2^2} \right] = \left(\frac{1}{0.4155} \right) \left[\frac{0.7^2}{0.4^2} \right] = 7.3706$$

Since the confidence interval has lower limit equal to 1.2357, a number that is above 1, these data are not consistent with the assumption of equal variances. (Logic – if the variances are equal, then their ratio is equal to 1. It then follows that, if the confidence interval for the ratio does not include 1, then the data are not consistent with the assumption of equal variances).

6. For the same data in problem #5 and drawing upon your answer to #5 (regarding the reasonableness of equality of variances), compute a 95% confidence interval for the true mean difference in FEV1 between 5-9 year old children whose parents smoke and comparable children whose parents do not smoke.

Answer: (-0.55, +0.15)

Solution:

This solution assumes that the variances are Unequal because the confidence interval obtained for #9 does **not** include a ratio of variances value = 1.

Therefore, the correct standard error formula to use is “Solution 3” on page 48 of the notes.

$$\bar{X}_1 - \bar{X}_2 = 2.1 - 2.3 = -0.2$$

$$SE[\bar{X}_1 - \bar{X}_2] = \sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}} = \sqrt{\frac{0.7^2}{23} + \frac{0.4^2}{20}} = 0.1712$$

$$f = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2} \right)^2}{\left(\frac{\left[\frac{S_1^2}{n_1} \right]^2}{n_1 - 1} + \frac{\left[\frac{S_2^2}{n_2} \right]^2}{n_2 - 1} \right)} = \frac{\left(\frac{0.7^2}{23} + \frac{0.4^2}{20} \right)^2}{\left(\frac{\left[\frac{0.7^2}{23} \right]^2}{22} + \frac{\left[\frac{0.4^2}{20} \right]^2}{19} \right)} = \frac{0.0008587}{0.000024} = 35.78 \approx 35 \text{ by rounding DOWN}$$

$$t_{1-\alpha/2;f} = t_{.975;DF=35} = 2.03$$

$$95\%CI = (\bar{X}_1 - \bar{X}_2) \pm (t_{.975;DF=35}) SE[(\bar{X}_1 - \bar{X}_2)] = (-0.2) \pm (2.03)(0.1712) = (-0.5475, +0.1475)$$