

Covered topics: descriptive statistics, simple random sample, one-way anova

Instructions: You may use your notes, and a calculator. Write your answers in the space provided. Total score is 20 points.

Question 1

Clouds were randomly seeded or not with silver nitrate. Rainfall amounts were recorded from the clouds. The purpose of the experiment was to determine if cloud seeding increases rainfall.

(a) [2 points] In the experiment, what is the response variable? The explanatory variable?

Answer: response variable = rainfall amount
explanatory variable = seeded or not seeded

(b) [2 points] According to the purpose of the experiment, set hypotheses H_0 and H_a and explain why.

Answer: H_0 : cloud seeding does not increase rainfall.
 H_a : cloud seeding increases rainfall. ($\mu_{seeded} \leq \mu_{not\ seeded}$)
($\mu_{seeded} > \mu_{not\ seeded}$)

The hypothesis we want to prove should be H_a .
(c) [2 points] Which one of the following statistical tests would you use to test the hypotheses in (b)?

- A. Chi-square test
- B. Paired t-test
- C. Two-sample t-test
- D. One-sample t-test

Answer: C

(d) [2 points] Suppose that the p-value of the test in (c) is 0.004. Write a sentence to interpret the meaning of the 0.004. State the conclusion of the test to the investigators of this experiment (non-statisticians).

Answer: The risk for rejecting H_0 is 0.004.
Since 0.004 is small (< 0.05), we conclude that cloud seeding does increase rainfall.

Question 2

The Merrimack Valley Pediatric Clinic (MVPC) conducted a customer satisfaction study at its four locations: 1=Amesbury, 2=Andover, and 3=Methuen in MA, and 4=Salem in southern New Hampshire. A series of questions were asked, and a respondent's "overall level of satisfaction" was computed by adding together the numerical scores to the various questions. The total score can be 16 to 80; a higher score represents a higher level of satisfaction. Marion Earle, MVPC's medical director, wanted to know if there were differences in the average level of satisfaction among customers in the four locations. Data from a random sample of 5 responders from each of the four locations were collected. Answer the following questions using the attached SPSS output.

- (a) [2 points] Are there significant differences in satisfaction among the 4 locations? Use $\alpha=0.05$.

Answer: Since the p-value .001 is less than 0.05, the α level, we can conclude that the satisfaction is significantly different in the 4 clinics.

- (b) [2 points] What two assumptions have you made in (a)?

Answer: ① The satisfaction follows a normal distribution for the 4 clinics.
② The variances of the satisfaction for the 4 clinics are equal.

- (c) [1 point] A test for one assumption is conducted and the output is attached. Is this assumption valid?

Answer: Levene's Test of Equality of Error Variances is conducted. Since the p-value is .924 > .05, this assumption is a reasonable one. (Note: SAS has a different p-value 0.6377.)

- (d) [2 points] The other assumption is not checked. State how you would check if this assumption is valid.

Answer: ① Do normality test for residuals.

② Draw a normal Q-Q (or P-P) plot. If this plot shows almost a line, the normality assumption is reasonable.

(e) [3 points] Express the conclusion of SNK tests for pairwise comparisons in practical terms.

Answer: Clinics 1, 2, 3 are not significantly different to each other in satisfaction but they are worse than Clinic 4 in satisfaction.

(f) [2 points] Ann lives next to the clinic Amesbury. She will go to another clinic if and only if that clinic has higher satisfaction than Amesbury. Ann would like to see doctor today, which one of the 4 clinics will she go?

Control = 1 (Amesbury)
Conduct Dunnett tests to compare clinics to the control. Only Salem (Clinic 4) is significantly better than Amesbury in satisfaction. So, Ann should go to Salem.

Univariate Analysis of Variance

Between-Subjects Factors

| | | N |
|----------|------|---|
| location | 1.00 | 5 |
| | 2.00 | 5 |
| | 3.00 | 5 |
| | 4.00 | 5 |

Levene's Test of Equality of Error Variances(a)

Dependent Variable: satisfaction

| F | df1 | df2 | Sig. |
|------|-----|-----|------|
| .157 | 3 | 16 | .924 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept+location

Tests of Between-Subjects Effects

Dependent Variable: satisfaction

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|-----------------|-------------------------|----|-------------|---------|------|
| Corrected Model | 115.093(a) | 3 | 38.364 | 8.760 | .001 |
| Intercept | 1017.594 | 1 | 1017.594 | 232.363 | .000 |
| location | 115.093 | 3 | 38.364 | 8.760 | .001 |
| Error | 70.069 | 16 | 4.379 | | |
| Total | 1202.756 | 20 | | | |
| Corrected Total | 185.162 | 19 | | | |

a R Squared = .622 (Adjusted R Squared = .551)

satisfaction

Student-Newman-Keuls

| location | N | Subset | |
|----------|---|--------|---------|
| | | 1 | 2 |
| 2.00 | 5 | 5.5760 | |
| 3.00 | 5 | 5.6920 | |
| 1.00 | 5 | 5.9840 | |
| 4.00 | 5 | | 11.2800 |
| Sig. | | .949 | 1.000 |

Means for groups in homogeneous subsets are displayed.

Based on Type III Sum of Squares

The error term is Mean Square(Error) = 4.379.

a Uses Harmonic Mean Sample Size = 5.000.

b Alpha = .05.

Multiple Comparisons

Dependent Variable: satisfaction

Dunnnett t (2-sided)

| (I) location | (J) location | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|--------------|--------------|-----------------------|------------|------|-------------------------|--------|
| 2.00 | 1.00 | -.4080 | 1.32353 | .980 | -3.8390 | 3.0230 |
| 3.00 | 1.00 | -.2920 | 1.32353 | .992 | -3.7230 | 3.1390 |
| 4.00 | 1.00 | 5.2960(*) | 1.32353 | .003 | 1.8650 | 8.7270 |

Based on observed means.

* The mean difference is significant at the .05 level.

a Dunnnett t-tests treat one group as a control, and compare all other groups against it.