

Test of population mean vs. hypothesized value, population standard deviation unknown







Exercise (13)

Exercise (13):

It is known that the mean Haemoglobin percent (Hb%) of adult females in a community is 89%. A researcher wanted to test whether pregnancy has a significant effect on hemoglobin level. He randomly selected 25 pregnant females and conducted measurement of their Hb level. The mean Hb% for the sample was of 86 ± 7%. The researcher selected level of significance α = 0.05. The critical value at df of 24 and level of significance 0.05 is 2.064.



I. Formulate general Research Question

I. Formulate general Research Question

Does pregnancy have significant effect on mean Hb%?



III. What is the appropriate test statistic?

Ho: $\mu = X$ (pregnancy has no significant effect on mean Hb%) Ho: $\mu \neq X$ (pregnancy has significant effect on mean Hb%)

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III. What is the appropriate test statistic?

One sample t test
$$t = \frac{\overline{X} - \mu_o}{s/\sqrt{n}}$$

Ho: $\mu = X$ (pregnancy has no significant effect on mean Hb%) Ho: $\mu \neq X$ (pregnancy has significant effect on mean Hb%)

III. What is the appropriate test statistic?

One sample t test
$$t = \frac{\overline{X} - \mu_o}{s/\sqrt{n}}$$

IV. What is the appropriate test Model? (One or Two tailed)

Two Tailed Test Model

Design Research Hypotheses and Experiment



V. Calculate test statistic

VI. Make a Decision regarding Research Hypotheses (Specify the Decision Method) V. Calculate test statistic

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} \qquad t = \frac{(86 - 89)}{7} = 2.14$$

VI. Make a Decision regarding Research Hypotheses (Specify the Decision Method) V. Calculate test statistic

$$t = \frac{\bar{X} - \mu_0}{s/\sqrt{n}} \qquad t = \frac{(86 - 89)}{7} = 2.14$$

VI. Make a Decision regarding Research Hypotheses (Specify the Decision Method)

Reject Null Hypothesis Ho

Test statistic (t=2.14) > critical value (2.064) (Critical value method)

Collect and Analyze Experimental Data







VII. Report a conclusion

VII. Report a conclusion

Pregnancy has a significant effect on mean Hb%.

The mean Hb% of pregnant females (86%) was significantly lower than the mean Hb% of adult females in the community (89%).

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The data is collected by two simple random samples from separate and unrelated populations. This data will then be used to compare the two population means. This is typical of an experimental or treatment population versus a control population.







Exercise (14)

Researchers were motivated to test a new antihypertensive drug (A) on a group of patients. They needed to know whether Drug (A) achieves significant reduction in the systolic blood pressure compared with the conventional antihypertensive drug (B).

In the current research, 200 randomly selected patients suffering from essential hypertension and fulfilled the inclusion and exclusion criteria were included. The participants were randomly allocated into two groups; 100 patients were given drug (A) and 100 were given the drug (B). The researchers selected level of significance $\alpha = 0.05$.

After a period of 10 weeks, the mean systolic blood pressure of the first group receiving drug (A) decreased by 12 ± 2.36 mm Hg while that of the second group decreased by 9 ± 5.69 . The collected data were typed onto computer and analyzed using SPSS software program. The program revealed the value of the test statistic=2.56 (p=0.06)



I. Formulate general Research Question

I. Formulate general Research Question

Is there any significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B)?



III. What is the appropriate test statistic?

Ho: $\overline{X}_1 = \overline{X}_2$ There is no significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B) Ha: $\overline{X}_1 \neq \overline{X}_2$

There is a significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B)

III. What is the appropriate test statistic?
Ho: $\overline{X}_1 = \overline{X}_2$ There is no significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B) Ha: $\overline{X}_1 \neq \overline{X}_2$

There is a significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B)

III. What is the appropriate test statistic?

Two Independent sample t test

$$t = \frac{(X_1 - X_2)}{\frac{S^2 p}{n_1} + \frac{S^2 p}{n_2}}$$

Ho: $\overline{X}_1 = \overline{X}_2$ There is no significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B) Ha: $\overline{X}_1 \neq \overline{X}_2$

There is a significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B)

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Two Independent sample t test

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IV. What is the appropriate test Model? (One or Two tailed)

Two Tailed Test Model

Design Research Hypotheses and Experiment

Procedures of Hypotheses Testing and the Scientific Method



V. Make a Decision regarding Research Hypotheses (Specify the Decision Method)

> Fail to Reject Null Hypothesis Ho P-value (0.6) > α (0.05)

> > (p-value method)

Collect and Analyze Experimental Data

Procedures of Hypotheses Testing and the Scientific Method



VI. Report a conclusion

VI. Report a conclusion

There is insufficient evidence to support the claim that there is a significant difference in the mean reduction of systolic blood pressure achieved by drug (A) and drug (B)





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The data consists of a single population and two measurements. A simple random sample is taken from the population and pairs of measurement are collected. This is also called related sampling or matched pair design.





 X_d is the sample mean of the differences of each pair S_d is the sample standard deviation of the differences of each pair

Matched pairs t-test

compares the means for two dependent populations (paired difference t-test)

Model Assumptions

Variable is quantitative continuous

Data is normally distributed

Dependent sampling

Matched pairs t-test

compares the means for two dependent populations (paired difference t-test)

Test Statistic

 S_{J}

$$t = \frac{\overline{X}_d - \mu_d}{s_d / \sqrt{n}} \qquad df = n - 1$$

$$\begin{array}{l} X_{d} = X_{1} - X_{2} \\ \overline{X}_{d} = \overline{X}_{1} - \overline{X}_{2} \end{array} \text{ approximately Normal} \end{array}$$

 X_d sample mean of the differences of each pair

sample standard deviation of the differences of each pair

Exercise (15)

Exercise (15):

An instructor of Anatomy course wants to know if student marks are different on the second midterm compared to the first exam after implementation of a new teaching intervention; TBL (team-based learning). The first and second midterm marks for 35 students were taken and the mean difference in marks is determined.



 X_d is the sample mean of the differences of each pair (2.05) S_d is the sample standard deviation of the differences of each pair

Diff	After Mark	Before Mark	Student
4	22	18	1
4	25	21	2
1	17	16	3
2	24	22	4
-3	16	19	5
5	29	24	6
3	20	17	7
-4	19	2	9
•		•	
4	19	15	34
-1	16	17	35
2.05	20.45	18.40	Mean

Data were typed and analyzed using SPSS software program. The level of significance was 0.05. The appropriate statistical test was conducted and revealed test statistic = 3.23 (p=0.004). The followings are SPSS output tables.

		Mean	N	Std. Deviation	Std. Error Mean
	Mark after	20.45	35	4.058	.907
Pair 1	Mark before	18.40	35	3.152	.705

Paired Samples Statistics

Paired Samples Test



Procedures of Hypotheses Testing and the Scientific Method



I. Formulate general Research Question

I. Formulate general Research Question

Is there a **difference** in students' marks following implementation of TBL (Team-based Learning)?

Procedures of Hypotheses Testing and the Scientific Method



III. What is the appropriate test statistic?

Ho: There is no difference in mean pre- and post-TBL marks H1: There is a difference in mean pre- and post-TBL marks

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Ho: There is no difference in mean pre- and post-TBL marks H1: There is a difference in mean pre- and post-TBL marks

III. What is the appropriate test statistic?

Matched pairs t-test

$$t = \frac{\overline{X}_d - \mu_d}{s_d / \sqrt{n}}$$
 $df = n - 1$

Ho: There is no difference in mean pre- and post-TBL marks H1: There is a difference in mean pre- and post-TBL marks

III. What is the appropriate test statistic?

Matched pairs t-test

$$t = \frac{\overline{X}_d - \mu_d}{s_d / \sqrt{n}}$$
 $df = n - 1$

IV. What is the appropriate test Model? (One or Two tailed)

Two Tailed Test Model

Design Research Hypotheses and Experiment

Procedures of Hypotheses Testing and the Scientific Method



Collect and Analyze Experimental Data

V. Make a Decision regarding Research Hypotheses (Specify the Decision Method) Data were typed and analyzed using SPSS software program. The level of significance was 0.05. The appropriate statistical test was conducted and revealed test statistic = 3.23 (p=0.004). The followings are SPSS output tables.

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Pair 1	Mark before	18.40	35	3.152	.705

Paired Samples Statistics

Paired Samples Test



V. Make a Decision regarding Research Hypotheses (Specify the Decision Method)

Reject Null Hypothesis Ho

P-value (0.004) < α (0.05) (p-value method)

Procedures of Hypotheses Testing and the Scientific Method


VI. Report a conclusion

VI. Report a conclusion

There is a strong evidence (t = 3.23, p = 0.004) that TBL as a teaching intervention improves students' marks. In this data set, it improved marks, on average, by approximately 2 points (mean paired difference =2.05).



 X_d is the sample mean of the differences of each pair (2.05) S_d is the sample standard deviation of the differences of each pair





Analy

Suppose we wanted to compare the means of more than two (k) independent populations and want to test the null hypothesis $Ho: \mu 1 = \mu 2 = \dots = \mu k$.

If we can assume all population variances are equal, we can expand the pooled variance t-test for two populations to one factor ANOVA for k populations.

If $Ho: \mu 1 = \mu 2 = \mu 3$ is true, then each population would have the same distribution and the variance of the combined data would be approximately the same.

If the *Ho* is false, then the difference between centers would cause the combined data to have an increased variance.



Data Requirements

- 1. Dependent variable that is continuous.
- 2. Independent variable (Factor) that is categorical (\geq 3 groups)
- 3. Cases that have values on both the dependent and independent variables

Data Requirements

4. Independent samples/groups (i.e., independence of observations); there is no relationship between the subjects in each sample.

This means that:

- A. subjects in the first group cannot also be in the second group
- B. no subject in either group can influence subjects in the other group
- C. no group can influence the other group

Data Requirements

- 5. Random sample of data from the population.
- 6. Normal distribution (approximately) of the dependent variable for each group (i.e., for each level of the factor)
- 7. Homogeneity of variances (i.e., variances approximately equal across groups)
- 8. No outliers

Model Assumptions

The populations being sampled are normally distributed

The populations have equal standard deviations

The samples are randomly selected and are independent

Research Hypotheses

 $H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_k$ ("all k population means are equal")

H_{a} : At least one μ_{i} different

("at least one of the k population means is not equal to the others")

Test Statistic

P-value	F	Mean Square (MS)	df	Sum of Squares (SS)	Source of Variation
	F=MS _{Factor} /MS _{Error}	MS _{Factor} =SS _{Factor} /K-1	k-1	SS _{Factor}	Factor (Between)
		MS _{Error} =SS _{Error} /n-k	n-k	SS _{Error}	Error (Within)
			n-1	SS _{Total}	Total

 SS_{Factor} = the regression sum of squares; SS_{Error} = the error sum of squares SS_{Total} = the total sum of squares (SST = SSR + SSE) k = the total number of groups; n = the total number of valid observations MS_{Factor} = the regression mean square; MS_{Error} = the mean square error

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct an exploratory analysis

Why?

- a) Examine descriptive statistics
- b) Check for outliers
- c) Check that the normality assumption is met
- d) Verify that there are mean differences between groups to justify ANOVA

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct One Way ANOVA

Why?

- 1. Determine whether group means are different form one another (warranting post hoc comparison tests)
- 2. Check that the homogeneity of variance assumption is met

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct Post hoc comparison test

Why?

To confirm where the differences occurred between groups

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Exercise (16)

Exercise (16)

A research was conducted to examine if there a difference in mean score of medical students at 4 universities located at different geographical locations (North-East, North-Central, South, and West region).

In order to conduct the research, 400 randomly selected students from the 4 universities were included, and their scores were reported. Data were typed and analyzed by SPSS software program. The statistician selected level of significance = 0.05.

I. State the Research Question

I. State the Research Question

Are there any differences in the mean score of medical students enrolled at North-East, North-Central, South, and West Universities?

II. State the Research Hypotheses

II. State the Research Hypotheses

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$

 $\begin{array}{l} \mu_{1:} \text{ mean score of students at North-East University} \\ \mu_{2:} \text{ mean score of students at North-Central University} \\ \mu_{3:} \text{ mean score of students at North-East University} \\ \mu_{4.} \text{ mean score of students at North-East University} \end{array}$

H_a : At least one μ_i different

("at least one of the 4 population means is not equal to the others")

III. Specify the Dependent and Independent variables Mention the type of variable and number of groups

Type of variable number of groups	Variable	
		Dependent Variable
		Independent Variable (Factor)

III. Specify the Dependent and Independent variables Mention the type of variable and number of groups

Type of variable number of groups	Variable	
Quantitative Continuous	Score	Dependent Variable
Categorical/Qualitative (4 groups)	Geographic Region of Medical School	Independent Variable (Factor)

Exercise (17)

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A manager of a pharmaceutical company wants to raise the productivity at his company by increasing the speed at which his pharmacists carry out pharmaceutical formulation.

As he does not have the skills in-house, he employs an external agency which provides training in pharmaceutical formulation Development. They offer 3 packages - a beginner, intermediate and advanced course.

He is unsure which course is needed for the type of work they do at his company so he sends 10 pharmacists on the beginner course, 10 on the intermediate and 10 on the advanced course.

Exercise (17)

When they all return from the training he gives them a task to formulate certain parenteral drug produced by the company and times how long it takes them to complete the task.

He wishes to then compare the three courses (beginner, intermediate, advanced) to see if there are any differences in the average time it took to complete the task.

The statistician selected level of significance = 0.05

I. State the Research Question

I. State the Research Question

Are there any differences in the average time taken by the pharmacists who attended the three training courses (Beginner, Intermediate, and Advanced courses), to complete the drug formulation task?

II. State the Research Hypotheses

II. State the Research Hypotheses

$H_0: \mu_1 = \mu_2 = \mu_3$

 $\mu_{1:}$ Mean time (hour) taken by the pharmacists who attended the beginner course to complete the task.

 $\mu_{2:}$ Mean time (hour) taken by the pharmacists who attended the intermediate course to complete the task.

 μ_3 : Mean time (hour) taken by the pharmacists who attended the advanced course to complete the task.

H_a : At least one μ_i different

("at least one of the 3 population means is not equal to the others")

III. Specify the Dependent and Independent variables Mention the type of variable and number of groups

Type of variable number of groups	Variable	
		Dependent Variable
		Independent Variable (Factor)
III. Specify the Dependent and Independent variables Mention the type of variable and number of groups

Type of variable number of groups	Variable	
Quantitative Continuous	Time	Dependent Variable
Categorical/Qualitative (3 groups)	Course	Independent Variable (Factor)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct an exploratory analysis

- a) Examine descriptive statistics
- b) Check for outliers

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

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Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Report READING STANDARDIZED SCORE										
COMPOSITE GEOGRAPHIC REGI	Mean	N	Std. Deviation	Variance	Skewness	Std. Error of Skewness				
NORTHEAST	55.8918	100	9.86641	97.346	486	.316				
NORTH CENTRAL	50.8328	100	10.01432	100.287	.224	.267				
SOUTH	51.3382	100	10.00440	100.088	.246	.241				
WEST	49.0311	100	9.81560	96.346	.502	.304				
Total	51.5901	400	10.14505	102.922	.152	.141				

Box plot graph



Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct an exploratory analysis

- a) Examine descriptive statistics
- b) Check for outliers
- c) Check that the normality assumption is met

Histogram



Tests of Normality





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Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Shapiro-Wilk Test of Normality

	Course	Kolm	ogorov-Smirn	ova	{	Shapiro-Wilk			
		Statistic	df	Sig.	Statistic	df	Sig.		
Time	Beginner	.177	10	.200*	.964	10	.827		
	Intermediate	.166	10	.200*	.969	10	.882		
	Advanced	.151	10	.200*	.965	10	.837		

Tests of Normality

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct an exploratory analysis

- a) Examine descriptive statistics
- b) Check for outliers
- c) Check that the normality assumption is met
- d) Verify that there are mean differences between groups to justify ANOVA

Error Bar graph



Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct an exploratory analysis

- a) Examine descriptive statistics
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Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct One Way ANOVA

- 1. Determine whether group means are different form one another (warranting post hoc comparison tests)
- 2. Check that the homogeneity of variance assumption is met

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Descriptives

Time

					95% Confiden Me	ice Interval for an		
	Ν	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Beginner	10	27.2000	3.04777	.96379	25.0198	29.3802	22.00	33.00
Intermediate	10	23.6000	3.30656	1.04563	21.2346	25.9654	18.00	29.00
Advanced	10	23.4000	3.23866	1.02415	21.0832	25.7168	18.00	29.00
Total	30	24.7333	3.56161	.65026	23.4034	26.0633	18.00	33.00

Test of Homogeneity of Variances



ANOVA

Time									
Sum of Squares	df	Mean Square	F	Sig.					
91.467	2	45.733	4.467	.021					
276.400	27	10.237							
367.867	29								
	Sum of Squares 91.467 276.400 367.867	Sum of Squaresdf91.4672276.40027367.86729	Sum of SquaresdfMean Square91.467245.733276.4002710.237367.86729	Sum of SquaresdfMean SquareF91.467245.7334.467276.4002710.23710.237367.8672910.23710.237					

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Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct One Way ANOVA

- 1. Determine whether group means are different form one another (warranting post hoc comparison tests)
- 2. Check that the homogeneity of variance assumption is met

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct Post hoc comparison test

Why?

To confirm where the differences occurred between groups

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One-Way ANOVA: Post Hoc Multiple Comparisons



Equal Variances As	sumed						
	<u>s-N-К</u>	Waller-Duncan					
Bonferroni	Tukey	Type I/Type II Error Ratio: 100					
C Sidak	Tukey's-b	Dunn <u>e</u> tt					
Scheffe	Duncan	Control Category : Last					
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R-E-G-W Q	<u>Gabriel</u>						
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Significance level: 0.05							
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		\frown					
Dependent Varial	ble:Time						
	(I) Course	(J) Course				95% Confide	ence Interval
			Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	Beginner	Intermediate	3.60000	1.43088	.046	.0523	7.1477
		Advanced	3.80000 [×]	1.43088	.034	.2523	7.3477
	Intermediate	Beginner	-3.60000 [°]	1.43088	.046	-7.1477	0523
		Advanced	.20000	1.43088	.989	-3.3477	3.7477
	Advanced	Beginner	-3.80000	1.43088	.034	-7.3477	2523
		Intermediate	20000	1.43088	.989	-3.7477	3.3477

Multiple Comparisons

READING STANDARDIZED SCORE

Tukey HSD						
					95% Confidence Interval	
(I) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	(J) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
NORTHEAST	NORTH CENTRAL	5.05891	1.71890	.018	.6178	9.5000
	SOUTH	4.55355*	1.65008	.031	.2903	8.8168
	WEST	6.86063*	1.82445	.001	2.1468	11.5744
NORTH CENTRAL	NORTHEAST	-5.05891*	1.71890	.018	-9.5000	6178
	SOUTH	50536	1.48624	.986	-4.3453	3.3346
	WEST	1.80171	1.67773	.706	-2.5330	6.1364
SOUTH	NORTHEAST	-4.55355*	1.65008	.031	-8.8168	2903
	NORTH CENTRAL	.50536	1.48624	.986	-3.3346	4.3453
	WEST	2.30707	1.60714	.478	-1.8453	6.4594
WEST	NORTHEAST	-6.86063*	1.82445	.001	-11.5744	-2.1468
	NORTH CENTRAL	-1.80171	1.67773	.706	-6.1364	2.5330
	SOUTH	-2.30707	1.60714	.478	-6.4594	1.8453
*. The mean difference	is significant at the 0.05 lev	el.				17 - AN

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Conduct Post hoc comparison test

Why?

To confirm where the differences occurred between groups
Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Return to Exercise (16)

ANOVA

READING STANDARDIZED SCORE Sum of Mean Square Sig. Squares F df .002 Between Groups 3 1513.532 504.511 5.104 Within Groups 29260.128 98.852 296 30773.660 Total 299

Multiple Comparisons

READING STANDARDIZED SCORE Tukey HSD

					95% Confidence Interval	
(I) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	(J) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
NORTHEAST	NORTH CENTRAL	5.05891*	1.71890	.018	.6178	9.5000
	SOUTH	4.55355*	1.65008	.031	.2903	8.8168
	WEST	6.86063*	1.82445	.001	2.1468	11.5744
NORTH CENTRAL	NORTHEAST	-5.05891*	1.71890	.018	-9.5000	6178
	SOUTH	50536	1.48624	.986	-4.3453	3.3346
	WEST	1.80171	1.67773	.706	-2.5330	6.1364
SOUTH	NORTHEAST	-4.55355	1.65008	.031	-8.8168	2903
	NORTH CENTRAL	.50536	1.48624	.986	-3.3346	4.3453
	WEST	2.30707	1.60714	.478	-1.8453	6.4594
WEST	NORTHEAST	-6.86063*	1.82445	.001	-11.5744	-2.1468
	NORTH CENTRAL	-1.80171	1.67773	.706	-6.1364	2.5330
	SOUTH	-2.30707	1.60714	.478	-6.4594	1.8453

*. The mean difference is significant at the 0.05 level.

READING STANDARDIZED	SCORE
INCADINO STANDANDIZED	SCOLL

COMPOSITE GEOGRAPHIC REGI	Mean	N	Std. Deviation	Variance	Skewness	Std. Error of Skewness
NORTHEAST	55.8918	100	9.86641	97.346	486	.316
NORTH CENTRAL	50.8328	100	10.01432	100.287	.224	.267
SOUTH	51.3382	100	10.00440	100.088	.246	.241
WEST	49.0311	100	9.81560	96.346	.502	.304
Total	51.5901	400	10.14505	102.922	.152	.141

Report

IV. Make your Decision regarding Research Hypotheses

ANOVA

READING STANDARDIZED SCORE Sum of Mean Square Sig. Squares F df .002 Between Groups 3 1513.532 504.511 5.104 Within Groups 29260.128 98.852 296 30773.660 Total 299

IV. Make your Decision regarding Research Hypotheses

Reject Null Hypothesis H_o

p-value of F statistic = 0.002 P-value < α 0.002 < 0.05

V. Report a conclusion

Multiple Comparisons

READING STANDARDIZED SCORE Tukey HSD

					95% Confidence Interval	
(I) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	(J) COMPOSITE GEOGRAPHIC REGION OF SCHOOL	Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
NORTHEAST	NORTH CENTRAL	5.05891*	1.71890	.018	.6178	9.5000
	SOUTH	4.55355*	1.65008	.031	.2903	8.8168
	WEST	6.86063*	1.82445	.001	2.1468	11.5744
NORTH CENTRAL	NORTHEAST	-5.05891*	1.71890	.018	-9.5000	6178
	SOUTH	50536	1.48624	.986	-4.3453	3.3346
	WEST	1.80171	1.67773	.706	-2.5330	6.1364
SOUTH	NORTHEAST	-4.55355	1.65008	.031	-8.8168	2903
	NORTH CENTRAL	.50536	1.48624	.986	-3.3346	4.3453
	WEST	2.30707	1.60714	.478	-1.8453	6.4594
WEST	NORTHEAST	-6.86063*	1.82445	.001	-11.5744	-2.1468
	NORTH CENTRAL	-1.80171	1.67773	.706	-6.1364	2.5330
	SOUTH	-2.30707	1.60714	.478	-6.4594	1.8453

*. The mean difference is significant at the 0.05 level.

READING STANDARDIZED	SCORE
INCADINO STANDANDIZED	SCOLL

COMPOSITE GEOGRAPHIC REGI	Mean	N	Std. Deviation	Variance	Skewness	Std. Error of Skewness
NORTHEAST	55.8918	100	9.86641	97.346	486	.316
NORTH CENTRAL	50.8328	100	10.01432	100.287	.224	.267
SOUTH	51.3382	100	10.00440	100.088	.246	.241
WEST	49.0311	100	9.81560	96.346	.502	.304
Total	51.5901	400	10.14505	102.922	.152	.141

Report

V. Report a conclusion

The mean score of medical students at North-East University was significantly higher (55.89±9.86) than the mean score of students at North-Central, West, and South Universities (50.83 ±10.01, 49.03±10.00, 51.33±9.8 respectively).

Return to Exercise (17)

ANOVA

Time					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	91.467	2	45.733	4.467	.021
Within Groups	276.400	27	10.237		
Total	367.867	29			

Multiple Comparisons

Dependent Variable: Time

	(I) Course	(J) Course				95% Confide	ence Interval
			Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	Beginner	Intermediate	3.60000	1.43088	.046	.0523	7.1477
		Advanced	3.80000 [×]	1.43088	.034	.2523	7.3477
	Intermediate	Beginner	-3.60000*	1.43088	.046	-7.1477	0523
		Advanced	.20000	1.43088	.989	-3.3477	3.7477
	Advanced	Beginner	-3.80000"	1.43088	.034	-7.3477	2523
		Intermediate	20000	1.43088	.989	-3.7477	3.3477

				Descriptive	S			
Time								
					95% Confiden Me	ice Interval for an		
	Ν	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Beginner	10	27.2000	3.04777	.96379	25.0198	29.3802	22.00	33.00
Intermediate	10	23.6000	3.30656	1.04563	21.2346	25.9654	18.00	29.00
Advanced	10	23.4000	3.23866	1.02415	21.0832	25.7168	18.00	29.00
Total	30	24.7333	3.56161	.65026	23.4034	26.0633	18.00	33.00

IV. Make your Decision regarding Research Hypotheses

ANOVA

Time					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	91.467	2	45.733	4.467	.021
Within Groups	276.400	27	10.237		
Total	367.867	29			

IV. Make your Decision regarding Research Hypotheses

Reject Null Hypothesis H_o

p-value of F statistic = 0.021 P-value < α 0.021 < 0.05

V. Report a conclusion

Multiple Comparisons

Dependent Variable: Time

	(I) Course	(J) Course				95% Confide	ence Interval
			Mean Difference (I- J)	Std. Error	Sig.	Lower Bound	Upper Bound
Tukey HSD	Beginner	Intermediate	3.60000	1.43088	.046	.0523	7.1477
		Advanced	3.80000 [×]	1.43088	.034	.2523	7.3477
	Intermediate	Beginner	-3.60000 [*]	1.43088	.046	-7.1477	0523
		Advanced	.20000	1.43088	.989	-3.3477	3.7477
	Advanced	Beginner	-3.80000"	1.43088	.034	-7.3477	2523
		Intermediate	20000	1.43088	.989	-3.7477	3.3477

				Descriptive	S			
Time								
					95% Confiden Me	ice Interval for an		
	Ν	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Beginner	10	27.2000	3.04777	.96379	25.0198	29.3802	22.00	33.00
Intermediate	10	23.6000	3.30656	1.04563	21.2346	25.9654	18.00	29.00
Advanced	10	23.4000	3.23866	1.02415	21.0832	25.7168	18.00	29.00
Total	30	24.7333	3.56161	.65026	23.4034	26.0633	18.00	33.00

V. Report a conclusion

Pharmacists who attended the Beginner course spent significantly longer duration of time to formulate the drug (27.20±3.04 hours) compared with Pharmacists who attended the Intermediate and the Advanced courses (23.60±3.30 hours, and 23.40±3.23 hours respectively).

Run a One Way ANOVA (SPPS's One Way ANOVA Procedure)

Comp (Para One F

Two F Indep

Depe

Analy



Thank you