**Chapter 13**

**Experimental Design and Analysis of Variance**

**Case Problem 1: Wentworth Medical Center**

Descriptive statistics for the individuals in reasonably good health (MEDICAL1) are shown below:

Variable N Mean Median TrMean StDev SEMean

FL 20 5.550 6.000 5.556 2.139 0.478

NY 20 8.000 8.000 7.944 2.200 0.492

NC 20 7.050 7.500 7.000 2.837 0.634

Variable Min Max Q1 Q3

FL 2.000 9.000 3.250 7.000

NY 4.000 13.000 7.000 8.750

NC 3.000 12.000 4.250 8.750

Descriptive statistics for the individuals who had a chronic health condition (MEDICAL2) are shown below:

Variable N Mean Median TrMean StDev SEMean

FL 20 14.500 14.500 14.444 3.171 0.709

NY 20 15.250 14.500 15.111 4.128 0.923

NC 20 13.950 14.000 14.000 2.946 0.659

Variable Min Max Q1 Q3

FL 9.000 21.000 12.000 17.000

NY 9.000 24.000 12.250 17.750

NC 8.000 19.000 12.000 16.750

The depression levels for the individuals who had a chronic health condition are, on average, much higher than the depression levels of individuals in reasonably good health.

The analysis of variance results for the individuals in reasonably good health (MEDICAL1) are shown below:

Analysis of Variance

Source DF SS MS F p

Factor 2 61.03 30.52 5.24 0.008

Error 57 331.90 5.82

Total 59 392.93

Individual 95% CIs For Mean

Based on Pooled StDev

Level N Mean StDev -+---------+---------+---------+-----

FL 20 5.550 2.139 (------\*------)

NY 20 8.000 2.200 (------\*-------)

NC 20 7.050 2.837 (------\*------)

-+---------+---------+---------+-----

Pooled StDev = 2.413 4.5 6.0 7.5 9.0

The *p*-value of .008 supports the conclusion that the mean depression scores are not the same for the three states. The observed differences appear to be due to the difference between the mean depression score for residents of Florida and New York.

The analysis of variance results for the individuals who had a chronic health condition (MEDICAL2) are shown below:

Analysis of Variance

Source DF SS MS F p

Factor 2 17.0 8.5 0.71 0.494

Error 57 679.7 11.9

Total 59 696.7

Individual 95% CIs For Mean

Based on Pooled StDev

Level N Mean StDev -------+---------+---------+---------

FL 20 14.500 3.171 (------------\*------------)

NY 20 15.250 4.128 (------------\*------------)

NC 20 13.950 2.946 (------------\*------------)

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Pooled StDev = 3.453 13.2 14.4 15.6

At the 5% level of significance there does not appear to be any significant difference in the mean depression scores among the three states.

**Case Problem 2: Compensation for Sales Professionals**

1. Descriptive statistics for Salary ($)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Experience** | | |  |
| **Position** |  | Low | Medium | High | Total |
| Inside | Number Obs. | 20 | 20 | 20 | 60 |
|  | Average | 55,031.35 | 55,607.75 | 57,422.45 | 56,020.52 |
|  | Std. Dev. | 3619.72 | 3544.74 | 3327.37 | 3589.83 |
| Outside | Number Obs. | 20 | 20 | 20 | 60 |
|  | Average | 64,607.90 | 81,628.50 | 75,254.90 | 73,830.43 |
|  | Std. Dev. | 3556.46 | 3453.47 | 3830.77 | 7922.96 |
| Total Number Obs. | | 40 | 40 | 40 | 120 |
| Total Average | | 59,819.63 | 68,618.13 | 66,338.68 | 64,925.48 |
| Total Std. Dev. | | 6005.06 | 13,621.38 | ,699.51 | 10,838.67 |

2. All sales positons: = $64,925.48 *n* = 120 = 1.980 (119 degrees of freedom)

= $64,925.48 1959.07

3. Inside sales positions: = $56,020.52 *n* = 60 = 2.001 (59 degrees of freedom)

= $56,020.52  927.35

4. Outside sales positions: = $73,830.43 *n* = 60 = 2.001 (59 degrees of freedom)

= $73,830.43  2046.72

5. The output using Minitab’s One-way ANOVA tool for Position is shown below:

Source DF SS MS F P

Factor 1 9515793950 9515793950 251.54 0.000

Error 118 4463949042 37830077

Total 119 13979742992

S = 6151 R-Sq = 68.07% R-Sq(adj) = 67.80%

Individual 95% CIs For Mean Based on

Pooled StDev

Level N Mean StDev ---------+---------+---------+---------+

Inside 60 56021 3590 (-\*--)

Outside 60 73830 7923 (--\*--)

---------+---------+---------+---------+

60000 66000 72000 78000

Pooled StDev = 6151

The *p*-value for Position is .000. Because the *p*-value is less than the level of significance, .05, Position is significant.

6. The output using Minitab’s One-way ANOVA tool for Experience is shown below:

Source DF SS MS F P

Factor 2 1668100099 834050050 7.93 0.001

Error 117 12311642893 105227717

Total 119 13979742992

S = 10258 R-Sq = 11.93% R-Sq(adj) = 10.43%

Individual 95% CIs For Mean Based on

Pooled StDev

Level N Mean StDev --------+---------+---------+---------+-

Low 40 59820 6005 (-------\*-------)

Medium 40 68618 13621 (-------\*-------)

High 40 66339 9700 (-------\*-------)

--------+---------+---------+---------+-

60000 64000 68000 72000

Pooled StDev = 10258

The *p*-value for Experience is .001. Because the *p*-value is less than the level of significance, .05, Experience is significant.

7. The output using Minitab’s Two-way ANOVA tool follows:

Source DF SS MS F P

Position 1 9.51579E+09 9515793950 751.36 0.000

Experience 2 1.66810E+09 834050050 65.86 0.000

Interaction 2 1.35207E+09 676033092 53.38 0.000

Error 114 1.44378E+09 12664761

Total 119 1.39797E+10

S = 3559 R-Sq = 89.67% R-Sq(adj) = 89.22%

Individual 95% CIs For Mean Based on Pooled StDev

Position Mean +---------+---------+---------+---------

Inside 56020.5 (-\*-)

Outside 73830.4 (-\*)

+---------+---------+---------+---------

55000 60000 65000 70000

Individual 95% CIs For Mean Based on

Pooled StDev

Experience Mean ----+---------+---------+---------+-----

High 66338.7 (---\*---)

Low 59819.6 (--\*---)

Medium 68618.1 (---\*--)

----+---------+---------+---------+-----

60000 63000 66000 69000

The *p*-values for Position, Experience, and Interaction are all .000. Because the *p*-values are less than the level of significance, .05, both factors and interaction are significant.