Test of Mean Differences Series Part 4: One-way ANOVA

Zin Htway, Ph.D., MBA, CT (ASCP, IAC)
Zin Htway, Ph.D., MBA, CT (ASCP, IAC)
Introduction to the One-way ANOVA

- A one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of two or more independent (unrelated) groups.
- A one-way ANOVA is an omnibus test statistic and cannot tell you which specific groups were statistically significantly different from each other; it only tells you that at least two groups were different.
Examples appropriate for the One-way ANOVA

• An example with four independent groups and a continuous outcome measure.
• The independent groups might be defined by a particular characteristic of the participants such as BMI (e.g., underweight, normal weight, overweight, obese)
• Randomizing participants to one of four competing treatments, call them A, B, C and D.
• Continuous outcome is systolic blood pressure, and we wish to test whether there is a statistically significant difference in mean systolic blood pressures among the four groups.
Statistical Assumptions of the One-way ANOVA

- Dependent variable should be measured on a continuous scale.
- Independent variable should consist of two or more categorical, independent groups.
- Independence of observations
- No significant outliers in the differences between the two related groups.
- Distribution of the differences in the dependent variable between the groups should be approximately normally distributed.
- There needs to be homogeneity of variances.
Essentials of the One-way ANOVA

- **Test:** One-way analysis of variance (ANOVA) [aka One-factor ANOVA]
- **Goal:** Compare three of more means.
- **Example:** A researcher might want to evaluate pulse rate of four groups of people, each group taking a different drug.
- **Additional Assumption:** All data sets sampled from Gaussian distributions with the same population standard deviations.
- **Effect size:** Fraction of the total variation explained by variation among group means (R-squared; also called eta-squared).
- **Null hypothesis:** All population means are equal.
- **Alternative hypothesis:** All population means are not equal.
- **Question the P value answers:** If all population means are identical, what is the chance of observing such a large variation among sample means by chance alone in an experiment of this size.
Follow-up tests to the One-way ANOVA

- **Test:** Tukeys multiple comparison test (aka Tukey-Kramer test)
- **Goal:** From three or more groups, compare every pair of means
- **Additional Assumption:** All data sets sampled from Gaussian distributions with the same population standard deviations.
- **Effect size:** A set of differences between every pair of means.
- **Confidence interval:** A set of confidence intervals for those differences (the CI level, usually 95% applies to the entire family of comparisons, not just one pair).
- **Null hypothesis:** All two population means are equal.
- **Alternative hypothesis:** All two population means are not equal.
- **Question the P value answers:** If all population means are identical, what is the chance of observing at least two means with such a large difference between them by chance alone in an experiment of this size.
Gaussian distribution (Normal, Bell-shaped curve)
Research questions

In there a difference in the annual sales revenue of Product A, Product B, and Product C?
Research questions

• Dependent variable = Sales Revenue
• Independent variable (Groups or Factors): Three separate products (A, B, C)
SPSS > Analyze > Compare Means > One-way ANOVA
Dependent List: Revenue (Scale)  
Factor: Prod_No [Prod_No]
Post_Hoc <click>
Tukey <select>
Continue <click>
Options <click>
Descriptive <select>
Homogeneity of variance test <select>
Continue <click>
ok <click>
## Descriptives

### Revenue

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
</tr>
<tr>
<td>Product A</td>
<td>401</td>
<td>669.870</td>
<td>259.93045</td>
<td>12.98031</td>
<td>644.3598</td>
<td>695.3962</td>
<td>153.62</td>
</tr>
<tr>
<td>Product B</td>
<td>396</td>
<td>791.825</td>
<td>270.55511</td>
<td>13.59591</td>
<td>765.0957</td>
<td>818.5545</td>
<td>218.59</td>
</tr>
<tr>
<td>Product C</td>
<td>203</td>
<td>785.897</td>
<td>214.92935</td>
<td>15.08508</td>
<td>756.1525</td>
<td>815.6413</td>
<td>377.96</td>
</tr>
<tr>
<td>Total</td>
<td>1000</td>
<td>741.720</td>
<td>262.29698</td>
<td>8.29456</td>
<td>725.4441</td>
<td>757.9976</td>
<td>153.62</td>
</tr>
</tbody>
</table>

- **N**: Number of observations
- **Mean**: Average value
- **Std. Deviation**: Standard deviation
- **Std. Error**: Standard error
- **95% Confidence Interval for Mean**: Lower and upper bounds of the confidence interval
- **Minimum** and **Maximum**: Range of values
Test of Homogeneity of Variances
Revenue

<table>
<thead>
<tr>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.076</td>
<td>2</td>
<td>997</td>
<td>.785</td>
</tr>
</tbody>
</table>
## ANOVA

### Revenue

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3460009.770</td>
<td>2</td>
<td>1730004.885</td>
<td>26.425</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>65270893.898</td>
<td>997</td>
<td>65467.296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>68730903.669</td>
<td>999</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Post Hoc Tests
#### Multiple Comparisons
#### Tukey HSA

<table>
<thead>
<tr>
<th>(I) Prod_No</th>
<th>(J) Prod_No</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>95% Confidence Interval</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Lower Bound</strong></td>
<td><strong>Upper Bound</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product A</td>
<td>Product B</td>
<td>-121.94706*</td>
<td>18.12682</td>
<td>.000</td>
<td>-164.4946</td>
</tr>
<tr>
<td></td>
<td>Product C</td>
<td>-116.01890*</td>
<td>22.03994</td>
<td>.000</td>
<td>-167.7513</td>
</tr>
<tr>
<td>Product B</td>
<td>Product A</td>
<td>121.94706*</td>
<td>18.12682</td>
<td>.000</td>
<td>79.3996</td>
</tr>
<tr>
<td></td>
<td>Product C</td>
<td>5.92817</td>
<td>22.08666</td>
<td>.961</td>
<td>-45.9139</td>
</tr>
<tr>
<td>Product C</td>
<td>Product A</td>
<td>116.01890*</td>
<td>22.03994</td>
<td>.000</td>
<td>64.2865</td>
</tr>
<tr>
<td></td>
<td>Product B</td>
<td>-5.92817</td>
<td>22.08666</td>
<td>.961</td>
<td>-57.7702</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the 0.05 level.
An analysis was conducted to determine if there is a difference in the annual revenue of Product A, Product B, and Product C. The analysis resulted a statistically significant difference between groups as determined by the One-way ANOVA \(F(2, 997) = 26.425, p < .001\). A Tukey post hoc revealed that the annual revenue was statistically significant between Product A and Product B \([-121.95, 95\% CI (-164.49, -79.40), p < .001\] and between Product A compared to Product C \([-116.02, 95\% CI (-167.75, -64.29), p < .001\]. There was no statistical significance between the annual revenue of Product B and Product C \(p = .961\).
Questions ???
More questions? Stay Informed!

Current Walden students, e-mail our tutoring team at:
AS Ctutoring@Waldenu.edu

Subscribe to our Facebook & Twitter channels to keep up-to-date on new information, ask questions and share your knowledge.

Subscribe to our YouTube channel (free!) to have instant access to new tutorials and webinar archives.

Visit our website for tutorials, event schedules, tutoring services, courses and workshops.