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Section E

The Unpaired t-test: More Examples
Example 1: CE Costs in Maryland

- Random sample of 500 Carotid Endarterectomy (CE) procedures performed in State of Maryland, 1995

- Some results:

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Charges (U.S. $)</td>
<td>6,615</td>
<td>7,088</td>
</tr>
<tr>
<td>SD (U.S. $)</td>
<td>4,220</td>
<td>4,908</td>
</tr>
<tr>
<td>N</td>
<td>271</td>
<td>229</td>
</tr>
</tbody>
</table>
Example 1: Boxplots!

- We actually have luxury of individual level data here
Example 1

- 95% CIs for 1995 CE costs by patient sex

  - Females: \( 7,088 \pm 2 \times \frac{4,908}{\sqrt{229}} \rightarrow 7,088 \pm 2 \times 324 \rightarrow ($6,440, $7,736) \)

  - Males: \( 6,615 \pm 2 \times \frac{4,220}{\sqrt{271}} \rightarrow 6,615 \pm 2 \times 256 \rightarrow ($6,103, $7,127) \)
Example 1

- Two sample t-test, unequal standard deviations assumption

```
ttesti 229 7088 4908 271 6615 4220, unequal
```

Two-sample t test with unequal variances

<table>
<thead>
<tr>
<th></th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>229</td>
<td>7088</td>
<td>324.3298</td>
<td>4908</td>
<td>6448.933 7727.067</td>
</tr>
<tr>
<td>y</td>
<td>271</td>
<td>6615</td>
<td>256.3467</td>
<td>4220</td>
<td>6110.307 7119.693</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>6831.634</td>
<td>203.4591</td>
<td>4549.404</td>
<td>6431.892 7231.376</td>
</tr>
<tr>
<td>diff</td>
<td></td>
<td>473</td>
<td>413.4047</td>
<td></td>
<td>-339.4305 1285.431</td>
</tr>
</tbody>
</table>

diff = mean(x) - mean(y)

Ho: diff = 0
Satterthwaite’s degrees of freedom = 452.669

Ha: diff < 0
Pr(T < t) = 0.8734

Ha: diff != 0
Pr(|T| > |t|) = 0.2532

Ha: diff > 0
Pr(T > t) = 0.1266
In a study conducted to assess determinants of CE procedure costs in Maryland, a random sample of 500 CE patients from 1995 was analyzed.

This consisted of 229 females with average costs of $7,088 (95% CI: 6,440 to 7,736), and 271 males with average costs $6,625 (95% CI: 6,103 to 7,127).

While the females in the sample had average costs of $473 greater than males in the samples, this difference in average costs is not statistically significant (p = .25).

- The 95% CI for the female to male average cost differential is $-339 to $1,285.
Example 2

- The following data is taken from a 1990 study comparing (random samples of) adolescents with bulimia to adolescents without bulimia; both groups had similar body composition and levels of physical activity*

- The following table shows summary data on daily calorie intake by bulimia status

<table>
<thead>
<tr>
<th></th>
<th>Bulimia</th>
<th>No Bulimia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Daily Caloric Intake (kcal/kg)</td>
<td>22.1</td>
<td>29.7</td>
</tr>
<tr>
<td>SD (kcal/kg)</td>
<td>4.6</td>
<td>6.5</td>
</tr>
<tr>
<td>N</td>
<td>23</td>
<td>15</td>
</tr>
</tbody>
</table>

Example 2

Abstract from article:

ABSTRACT: Patients with bulimia (binge-purge syndrome) frequently complain that they consume a very restrictive diet to avoid gaining weight. To investigate this claim, 23 hospitalized bulimic patients were assessed daily for body weight, caloric intake, macronutrient diet content, activity measures, and body composition estimates during weight-stable periods. Bulimic patients ate fewer kilocalories per kilogram body weight (22.1 ± 4.6 kcal/kg) than did age-matched normal women (29.7 ± 6.5 kcal/kg) but had similar activity levels and body composition. Clinical variables, such as history of laxative abuse, anorexia, or obesity, and physiological characteristics, such as body weight, activity level, or dietary content, could not account for this difference in caloric consumption. Bulimic patients tended to eat a diet lower in fat and higher in protein than did control subjects. These results agree with observations of increased efficiency of caloric utilization in obese patients and support patient complaints of a tendency to gain weight easily.
Abstract from article:

ABSTRACT: Patients with bulimia (binge-purge syndrome) frequently complain that they consume a very restrictive diet to avoid gaining weight. To investigate this claim, 23 hospitalized bulimic patients were assessed daily for body weight, caloric intake, macronutrient diet content, activity measures, and body composition estimates during weight-stable periods. Bulimic patients ate fewer kilocalories per kilogram body weight (22.1 ± 4.6 kcal/kg) than did age-matched normal women (29.7 ± 6.5 kcal/kg) but had similar activity levels and body composition. Clinical variables, such as history of laxative abuse, anorexia, or obesity, and physiological characteristics, such as body weight, activity level, or dietary content, could not account for this difference in caloric consumption. Bulimic patients tended to eat a diet lower in fat and higher in protein than did control subjects. These results agree with observations of increased efficiency of caloric utilization in obese patients and support patient complaints of a tendency to gain weight easily.
Example 2: Boxplots

- Again, luxury of individual level data:

![Boxplot of Daily Caloric Intake by Subject's Bulimia Status](image-url)
Example 2

- 95% CIs for average daily calorie intake by bulimia status

  - Bulimia: $22.1 \pm t_{.95,22} \times \frac{4.6}{\sqrt{23}} \rightarrow 22.1 \pm 2.07 \times .96 \approx (20.1 \text{ kcal/kg}, 24.1 \text{ kcal/kg})$

  - No bulimia: $29.7 \pm t_{.95,14} \times \frac{6.5}{\sqrt{15}} \rightarrow 29.7 \pm 2.14 \times 1.7 \rightarrow (26.1 \text{ kcal/kg}, 33.3 \text{ kcal/kg})$
Example 2 in Stata

- Two sample t-test, unequal standard deviations assumption:

```stata
. ttesti 23 22.1 4.6 15 29.7 6.5, unequal
```

<table>
<thead>
<tr>
<th></th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Err.</th>
<th>Std. Dev.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>23</td>
<td>22.1</td>
<td>.9591663</td>
<td>4.6</td>
<td>20.11081  24.08919</td>
</tr>
<tr>
<td>y</td>
<td>15</td>
<td>29.7</td>
<td>1.678293</td>
<td>6.5</td>
<td>26.10042  33.29958</td>
</tr>
<tr>
<td>combined</td>
<td>38</td>
<td>25.1</td>
<td>1.06055</td>
<td>6.537666</td>
<td>22.95112  27.24888</td>
</tr>
<tr>
<td>diff</td>
<td>38</td>
<td>-7.6</td>
<td>1.933046</td>
<td>-11.59811</td>
<td>-3.601887</td>
</tr>
</tbody>
</table>

- Satterthwaite's degrees of freedom = 23.0727
- $t = -3.9316$

Ho: diff = 0

Ha: diff < 0
Pr(T < t) = 0.0003

Ha: diff != 0
Pr(|T| > |t|) = 0.0007

Ha: diff > 0
Pr(T > t) = 0.9997
Summary

- From the article:

**FIG 1.** Normal-weight bulimic patients \((n = 23)\) had significantly lower caloric intake per kilogram body weight than age- and sex-matched volunteers \((n = 15)\). This was highly significant \((p < 0.001)\)