DSO 545
Statistical Analysis & Data Visualization
F. Pereira

Two Sample Hypothesis Test

Review

Announcements

HW#5

Due 11/21 @ 1159 PM

Agenda

- Plotly Histograms
- Plotly Box-plots
- 2 Sample Test

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Pfizer

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NEWS / Pfizer and BioNTech Announce Publication of Results from Landmark Phase 3 Trial of BNT162b2 COVID-19 Vaccine Candidate in The New England Journal of Medicine

PFIZER AND BIONTECH ANNOUNCE PUBLICATION OF RESULTS FROM LANDMARK PHASE 3 TRIAL OF BNT162B2 COVID-19 VACCINE CANDIDATE IN THE NEW ENGLAND JOURNAL OF MEDICINE

Thursday, December 10, 2020 - 10:21am

- *Data from 43,448 participants, half of whom received BNT162b2 and half of whom received placebo, showed that the vaccine candidate was well tolerated and demonstrated 95% efficacy in preventing COVID-19 in those without prior infection 7 days or more after the second dose*
- *Vaccine efficacy observed in the overall study population was also generally consistent across subgroups defined by age, gender, race, ethnicity, baseline body mass index (BMI), or presence of other underlying co-morbidities*
- *Partial protection from the vaccine candidate appears to begin as early as 12 days after the first dose*
- *These data were included in the requests for regulatory authorization submitted to regulatory agencies across the globe, including the U.S. Food and Drug Administration and the European Medicines Agency*

Among 36,523 participants who had no evidence of existing or prior SARS-CoV-2 infection by the time of the immunizations, there were 170 cases of COVID-19 observed with onset at least 7 days after the second dose; 8 cases occurred in vaccine recipients, and 162 in placebo recipients, corresponding to 95.0% vaccine efficacy (95% credible interval [CI, 90.3, 97.6]). Among participants with and without evidence of prior SARS CoV-2 infection, there were 9 cases of COVID-19 among vaccine recipients and 169 among placebo recipients, corresponding to 94.6% vaccine efficacy (95% CI [89.9, 97.3]).

Placebo Vaccine

Marketing and Consumer Profile

Analytics in Action

A/B Testing: Old Technique, New Application

A/B testing is used to compare customers' reactions to differences in website design. The basic concept of A/B testing uses two-sample statistical hypothesis testing based on techniques developed a hundred years ago by a statistician named Ronald Fisher. While the fundamentals of the statistics haven't changed, what has changed is the technology as well as *how* the data are collected and the *quantity* of data collected. The Internet has made it possible to collect millions of customer responses on different website layouts in real time.

When designing an online retail web page, developers consider text differences (e.g., font and color), pay button differences (e.g., placement and size), user device choice (e.g., mobile or desktop), and many others. The number of combinations to consider is extremely large. To deal with the size of this problem, statisticians use multivariate A/B tests comparing customer responses from two, three, or even four website designs at a time. Results are analyzed using significance levels and margins of error—statistical terms that you've already learned about. A/B testing helps retailers design websites that increase the chance that a customer will buy their products. Examples of changes companies have made after testing include:

- Offering health service packages with a quoted package price rather than individual service pricing.
- Removing discount codes when customers only want to make a purchase.
- Simplifying text on a landing page rather than including detailed information.
- Posting photos that show customers in action versus photos with static poses.

Source: https://hbr.org/2017/06/a-refresher-on-ab-testing.

Should the marketing campaign/Ads for Males be different than for Females?

Two-Sample Hypothesis Tests

Early Intervention Saves Lives

Statistics is helping U.S. hospitals prove the value of innovative organizational changes to deal with medical crisis situations. At the Pittsburgh Medical Center, “SWAT teams” were shown to reduce patient mortality by cutting red tape for critically ill patients. They formed a Rapid Response Team (RRT) consisting of a critical care nurse, intensive care therapist, and respiratory therapist, empowered to make decisions without waiting until the patient’s doctor could be paged. Statistics were collected on cardiac arrests for 2 months before and after the RRT concept was implemented. The sample data revealed more than a 50 percent reduction in total cardiac deaths and a 46 percent decline in average ICU days after cardiac arrest from 2.59 days to only 1.50 days after RRT. These improvements were both *statistically significant* and of *practical importance* because of the medical benefits and the large cost savings in hospital care. Statistics played a similar role at the University of California San Francisco Medical Center in demonstrating the value of a new method of expediting treatment of heart attack emergency patients. (See “How Statistics Can Save Failing Hearts,” *The New York Times,* March 7, 2007, p. C1.)

BEFORE → New system → AFTER

Does the introduction of a new system improve efficiency or saves more lives?

Do USC graduates earn more than UCLA graduates?

	
University of California--Los Angeles	University of Southern California

Average Alumni Starting Salaries

$56,600	$58,100

USCMarshall
School of Business

Two-Sample Tests

What is a Two-Sample Test

- A Two-sample test compares two sample estimates with each other.
- A one-sample test compares a sample estimate to a non-sample benchmark.

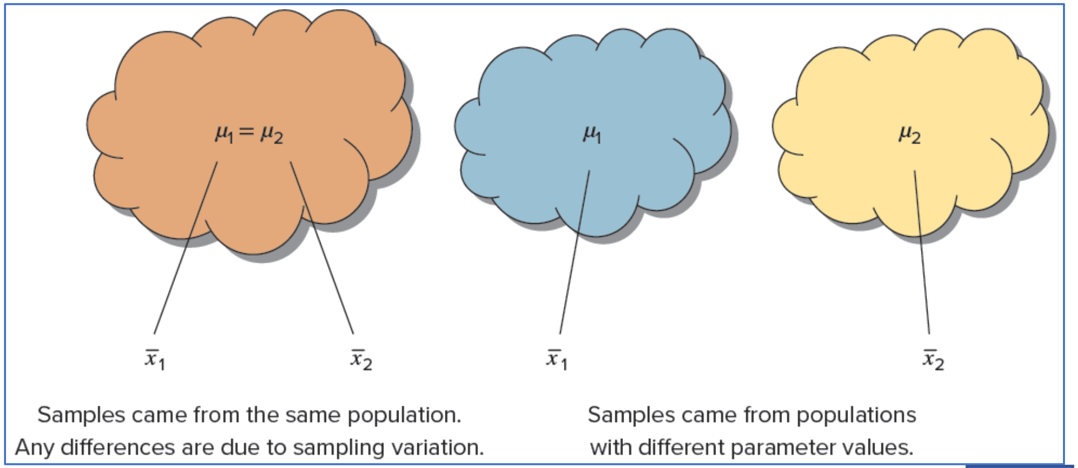
Basis of Two-Sample Tests

- Two-sample tests are especially useful because they possess a built-in point of comparison.

- Before *versus* after
- Old *versus* new
- Experimental *versus* control

Two-Sample Tests

- The logic of two-sample tests is based on the fact that two samples drawn from the same population may yield different estimates of a parameter due to chance.



$\bar{X}_1 - \bar{X}_2 \neq 0$ ⇒ $E\{\bar{X}_1 - \bar{X}_2 \neq 0$?

If two sample statistics differ by more than the amount attributable to chance can we conclude that the samples came from populations with different parameter values

Comparing Two Means: Independent Samples

For most cases we will be testing if the difference =0 or < or < 0

Format of Hypotheses

One-Tail Lower

One-Tail Upper

Left-Tailed Test	*Two-Tailed Test*	*Right-Tailed Test*
$H_0: \mu_1 - \mu_2 \geq 0$	$H_0: \mu_1 - \mu_2 = 0$	$H_0: \mu_1 - \mu_2 \leq 0$
$H_1: \mu_1 - \mu_2 < 0$	$H_1: \mu_1 - \mu_2 \neq 0$	$H_1: \mu_1 - \mu_2 > 0$

The direction of the test is indicated by H_1:

Comparing Two Means: Independent Samples

Case 1: Known Variances

- For the case where we know the values of the population variances, σ_1^2 and σ_2^2, the test statistic is a *z*-score.

$$z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{{\sigma_1}^2}{n_1} + \frac{{\sigma_2}^2}{n_2}}}$$

Comparing Two Means: Independent Samples

Case 2: Unknown Variances, Assumed Equal

- Since the variances are unknown, they must be estimated and the Student's *t* distribution used to test the means.
- Assuming the population variances are equal, s_1^2 and s_2^2 can be used to estimate a common pooled variance s_p^2.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$s^2 = \frac{\sum_{i=1}^{n_1}(x_i - \bar{x}_1)^2 + \sum_{j=1}^{n_2}(x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

Comparing Two Means: Independent Samples

Case 3: Unknown Variances, Assumed Unequal

- Since the variances are unknown, they must be estimated and the Student's *t* distribution used to test the means.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

Comparing Two Means: Independent Samples

Example

Case 2: Unknown Variances, Assumed Equal

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$s^2 = \frac{\sum_{i=1}^{n_1}(x_i - \bar{x}_1)^2 + \sum_{j=1}^{n_2}(x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

Python Code

```
stats.ttest_ind(a=GP1, b=GP2,equal_var=True)
```

```
Ttest_indResult(statistic=-0.9397150557667203, pvalue=0.3479336973939533)
```