GENERAL

how to calculate 95 confidence interval

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How to Calculate a 95% Confidence Interval: A Step by Step Guide

When you conduct research or analyze data, you often need to express the uncertainty surrounding an estimate. A **confidence interval (CI)** gives you a range that is likely to contain the true population parameter. The most common choice is a 95% CI, which means that if you repeated the study many times, about 95% of the calculated intervals would include the true value.

In this article we will walk through the theory behind confidence intervals, explain how to calculate a 95% CI for different types of data, and provide practical examples and tools. By the end, you'll be able to compute confidence intervals manually, verify them with software, and interpret the results confidently.

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What Is a Confidence Interval?

A confidence interval is a range of values, derived from a sample, that is likely to contain the true value of an unknown population parameter. It is expressed as:

Estimate ± Margin of Error

The **estimate** is usually a sample statistic (e.g., sample mean, sample proportion). The **margin of error** quantifies the precision of the estimate and depends on the variability of the data and the sample size.

Mathematically, a 95% CI for a population mean ;À is defined as the set of all values ;€ such that the probability of the interval covering ;Â —2 “RS

P(;…öÆðw "d ;Â &B ¸_high) = 0.95

Why 95%?

Statisticians often choose 95% because it balances precision and confidence. A 90% CI is narrower but offers less assurance; a 99% CI is more conservative but wider. The 95% level is conventionally used in many fields—from

medical trials to social science research—because it provides a reasonable trade off between the risk of missing the true parameter and the cost of a wide interval.

Basic Formula for a 95% Confidence Interval

For a normally distributed population with known variance, the 95% CI for the mean ;Â —3

;, Ò 3 ± z* × (<2 ò !¦â•

#0sample mean**<0**population standard deviation (often unknown; see below)**n** – sample size**z*** – critical value from the standard normal distribution that captures 95% of the area ("H 1.96)

When **<0** unknown, we replace it with the sample standard deviation s and use the **t distribution** instead of the normal distribution. The critical value then becomes t*, which depends on the degrees of freedom (df = n – 1).

Confidence Interval for a Sample Mean

Case 1: Known Population Standard Deviation

Suppose you have a sample of 50 students' test scores. The population standard deviation is known to be 10 points. The sample mean is 75.

1. Calculate the standard error (SE):

SE = <2 ò !¦â Ò ò !£S $, ãC @

Find the critical z value for 95% confidence (z* = 1.96).
Compute the margin of error (MOE):

MOE = z* × SE = 1.96 × 1.414 "H 2.77

Construct the interval:

Lower bound = 75 – 2.77 = 72.23
Upper bound = 75 + 2.77 = 77.77

Thus, the **72.23 to 77.77** population mean is

Case 2: Unknown Population Standard Deviation (Most Real World Situations)

Now assume we only know the sample standard deviation s = 12 and the sample mean #0 = 75 from a sample of n = 30.

1. Compute the standard error:

SE = s / " n = 12 / " 30 "H 2.19

Determine the t critical value for 95% confidence with df = n – 1 = 29. From a t table or calculator, t* "H 2.045.
Margin of error:

MOE = t* × SE = 2.045 × 2.19 "H 4.48

Construct the interval:

Lower bound = 75 – 4.48 = 70.52
Upper bound = 75 + 4.48 = 79.48

70.52 to 79.48 The 95% CI is therefore

Confidence Interval for a Sample Proportion

When estimating a population proportion p (e.g., the percentage of voters favoring a policy), the standard error is based on the binomial distribution:

SE = " [p0" ƒ b) / n]

where p0" —2 F†R 6 × ÆR &÷ ÷ tion.

Example: Political Poll

A poll of 1,000 voters found that 520 support Candidate A. Compute the 95% CI for the true support proportion.

1. Sample proportion:

p0" Ò S# ò Ò ãS

Standard error:

SE = " [0.52 × (1 – 0.52) / 1000] "H " [0.52 × 0.48 / 1000] "H " [0.2496 / 1000] "H " 0.0002496 "H 0.0158

Critical z value: 1.96.
Margin of error:

MOE = 1.96 × 0.0158 "H 0.0310

Confidence interval:

Lower bound = 0.52 – 0.0310 = 0.489
Upper bound = 0.52 + 0.0310 = 0.551

So, we are 95% confident that the true proportion of supporters lies between **48.9% and 55.1%**.

Small Sample Sizes and the t Distribution

When the sample size is small (n < 30), the sampling distribution of the mean is better approximated by the t distribution rather than the normal distribution. The t distribution has heavier tails, which leads to a slightly larger

critical value and a wider interval, reflecting the increased uncertainty.

To calculate a 95% CI with the t distribution:

1. Compute the standard error using the sample standard deviation.
2. Determine the degrees of freedom: df = n – 1.
3. Find t* from a t table or calculator for 95% confidence.
4. Proceed with the margin of error and interval construction as before.

Non Normal Data and Transformations

In practice, data may not follow a normal distribution. The central limit theorem (CLT) states that the sampling distribution of the mean approaches normality as the sample size grows, but for very skewed data or small samples, the CLT may not hold well.

Strategies for Non Normal Data

- Data Transformation: Apply a log, square root, or Box Cox transformation to reduce skewness. Compute the CI on the transformed scale and then back transform the limits.
- Bootstrap Confidence Intervals: Resample the data many times (with replacement) to empirically estimate the sampling distribution and derive percentile or bias corrected bootstrap intervals.
- Non Parametric Methods: Use methods like the Mann–Whitney U test or the Wilcoxon signed rank test, which do not rely on normality assumptions, though they typically provide tests rather than intervals.

Bootstrap Example

Suppose you have 12 measurements of a new drug's effect size. You resample 10,000 times, compute the mean each time, and find that the 2.5th and 97.5th percentiles of the bootstrap distribution are 3.2 and 5.8, respectively. The 95% bootstrap CI is then **3.2 to 5.8**.

Confidence Intervals in Practice

Below are common scenarios where confidence intervals are used, along with brief guidance on calculation.

1. Clinical Trials

- Estimate the mean difference in blood pressure between treatment and placebo groups.
- Use a two sample t interval if variances are equal or Welch's t interval if unequal.
- Report the 95% CI alongside the p value to convey both significance and precision.

2. Market Research

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