# How to Use a Chi-Square Distribution Table to Find Probability Values

Authored by
**stats writer**

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The Chi-Square Distribution Table is an essential statistical tool used primarily to determine the probability of observing a particular test statistic, which is calculated during a chi-square hypothesis test. This table is structured to help researchers make informed decisions about whether to reject the null hypothesis.

Understanding how to navigate this table is critical for proper statistical inference. The table is typically organized with degrees of freedom displayed along one axis (usually the rows) and critical probability or alpha level values along the other axis (usually the columns). By cross-referencing these two parameters, one can find the critical value necessary for interpreting experimental data. This comprehensive tutorial will guide you through interpreting the table and applying it to various types of chi-square tests.

This tutorial explains how to read and interpret critical values for hypothesis testing.

## What is the Chi-Square Distribution Table and How to Use It?

The Chi-Square distribution table serves as a comprehensive reference that lists the critical values corresponding to the Chi-Square distribution curve. These critical values are essential for determining the statistical significance of results obtained from a chi-square test. To effectively utilize this table, researchers must identify two primary inputs based on their study design:

The degrees of freedom (df) calculated specifically for the performed Chi-Square test.
The predetermined alpha level ($alpha$) chosen for the test (common choices are 0.01, 0.05, and 0.10).

The table is structured systematically to facilitate easy lookup. Generally, the degrees of freedom are indexed along the vertical axis (rows), while the common alpha level thresholds are placed across the horizontal axis (columns). The intersection of a specific degree of freedom and an alpha level yields the critical value.

The image below illustrates the structure of the initial rows of a standard Chi-Square distribution table, clearly showing the arrangement of degrees of freedom on the left and alpha levels across the top.

***Note:*** *Comprehensive Chi-Square distribution tables often extend beyond 20 rows to accommodate a wider range of degrees of freedom.*

| | P | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 0.995 | 0.975 | 0.2 | 0.1 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.002 | 0.001 |
| 1 | .0004 | .00016 | 1.642 | 2.706 | 3.841 | 5.024 | 5.412 | 6.635 | 7.879 | 9.55 | 10.828 |
| 2 | 0.01 | 0.0506 | 3.219 | 4.605 | 5.991 | 7.378 | 7.824 | 9.21 | 10.597 | 12.429 | 13.816 |
| 3 | 0.0717 | 0.216 | 4.642 | 6.251 | 7.815 | 9.348 | 9.837 | 11.345 | 12.838 | 14.796 | 16.266 |
| 4 | 0.207 | 0.484 | 5.989 | 7.779 | 9.488 | 11.143 | 11.668 | 13.277 | 14.86 | 16.924 | 18.467 |
| 5 | 0.412 | 0.831 | 7.289 | 9.236 | 11.07 | 12.833 | 13.388 | 15.086 | 16.75 | 18.907 | 20.515 |
| 6 | 0.676 | 1.237 | 8.558 | 10.645 | 12.592 | 14.449 | 15.033 | 16.812 | 18.548 | 20.791 | 22.458 |
| 7 | 0.989 | 1.69 | 9.803 | 12.017 | 14.067 | 16.013 | 16.622 | 18.475 | 20.278 | 22.601 | 24.322 |
| 8 | 1.344 | 2.18 | 11.03 | 13.362 | 15.507 | 17.535 | 18.168 | 20.09 | 21.955 | 24.352 | 26.124 |
| 9 | 1.735 | 2.7 | 12.242 | 14.684 | 16.919 | 19.023 | 19.679 | 21.666 | 23.589 | 26.056 | 27.877 |
| 10 | 2.156 | 3.247 | 13.442 | 15.987 | 18.307 | 20.483 | 21.161 | 23.209 | 25.188 | 27.722 | 29.588 |
| 11 | 2.603 | 3.816 | 14.631 | 17.275 | 19.675 | 21.92 | 22.618 | 24.725 | 26.757 | 29.354 | 31.264 |
| 12 | 3.074 | 4.404 | 15.812 | 18.549 | 21.026 | 23.337 | 24.054 | 26.217 | 28.3 | 30.957 | 32.909 |
| 13 | 3.565 | 5.009 | 16.985 | 19.812 | 22.362 | 24.736 | 25.472 | 27.688 | 29.819 | 32.535 | 34.528 |
| 14 | 4.075 | 5.629 | 18.151 | 21.064 | 23.685 | 26.119 | 26.873 | 29.141 | 31.319 | 34.091 | 36.123 |
| 15 | 4.601 | 6.262 | 19.311 | 22.307 | 24.996 | 27.488 | 28.259 | 30.578 | 32.801 | 35.628 | 37.697 |
| 16 | 5.142 | 6.908 | 20.465 | 23.542 | 26.296 | 28.845 | 29.633 | 32 | 34.267 | 37.146 | 39.252 |
| 17 | 5.697 | 7.564 | 21.615 | 24.769 | 27.587 | 30.191 | 30.995 | 33.409 | 35.718 | 38.648 | 40.79 |
| 18 | 6.265 | 8.231 | 22.76 | 25.989 | 28.869 | 31.526 | 32.346 | 34.805 | 37.156 | 40.136 | 42.312 |
| 19 | 6.844 | 8.907 | 23.9 | 27.204 | 30.144 | 32.852 | 33.687 | 36.191 | 38.582 | 41.61 | 43.82 |
| 20 | 7.434 | 9.591 | 25.038 | 28.412 | 31.41 | 34.17 | 35.02 | 37.566 | 39.997 | 43.072 | 45.315 |

Once the critical value is identified, it is directly compared against the calculated test statistic from the experiment. A fundamental rule in hypothesis testing is applied here: if the calculated test statistic exceeds the critical value obtained from the table, it indicates that the observed deviation is too large to be attributed to random chance alone. Consequently, we must reject the null hypothesis, concluding that the findings are statistically significant at the chosen alpha level.

## Applying the Chi-Square Distribution Table: Case Studies

To solidify the understanding of critical values and table usage, we will now examine practical applications across the three main categories of Chi-Square statistical analysis. While all these tests rely on the same distribution table for critical values, the calculation of the degrees of freedom differs based on the test's structure and purpose.

We will walk through detailed examples for each of the following important Chi-Square tests:

The **Chi-Square Test for Independence**
The **Chi-Square Test for Goodness of Fit**
The **Chi-Square Test for Homogeneity**

These examples will illustrate how the calculated test statistic is benchmarked against the table's critical value to draw statistical conclusions regarding the relationship between variables or the adherence to a hypothesized distribution.

## Chi-Square Test for Independence

The **Chi-Square test for independence** is utilized when the objective is to assess whether a statistically significant relationship or association exists between two distinct categorical variables. The null hypothesis for this test always assumes that the two variables are independent of one another (i.e., there is no association).

**Example Scenario:** Imagine a study designed to investigate whether a voter's gender is associated with their political party preference. A large, simple random sample of 500 voters is collected, and their preferences are recorded. For this analysis, we establish a level of significance ($alpha$) of 0.05. The primary goal is to determine if the differences in party preference observed between genders are statistically significant or merely due to sampling error. The following contingency table summarizes the survey results:

| | Republican | Democrat | Independent | Total |
|---|---|---|---|---|
| **Male** | 120 | 90 | 40 | 250 |
| **Female** | 110 | 95 | 45 | 250 |
| **Total** | 230 | 185 | 85 | 500 |

After performing the necessary calculations on the observed and expected frequencies, the calculated test statistic for this specific Chi-Square test is determined to be 0.864. The next crucial step is locating the corresponding critical value using the Chi-Square distribution table.

To find the critical value for the Test of Independence, we must first calculate the degrees of freedom (df). The formula is (Number of Rows - 1) $times$ (Number of Columns - 1). Given a 2x3 table (2 rows, 3 columns), the calculation is: $df = (2-1) times (3-1) = 2$. We then reference the Chi-Square table using $df=2$ and the specified alpha level of 0.05. Consulting the table reveals that the critical value for these parameters is **5.991**.

| | P | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 0.995 | 0.975 | 0.2 | 0.1 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.002 | 0.001 |
| 1 | .0004 | .00016 | 1.642 | 2.706 | 3.841 | 5.024 | 5.412 | 6.635 | 7.879 | 9.55 | 10.828 |
| 2 | 0.01 | 0.0506 | 3.219 | 4.605 | 5.991 | 7.378 | 7.824 | 9.21 | 10.597 | 12.429 | 13.816 |
| 3 | 0.0717 | 0.216 | 4.642 | 6.251 | 7.815 | 9.348 | 9.837 | 11.345 | 12.838 | 14.796 | 16.266 |
| 4 | 0.207 | 0.484 | 5.989 | 7.779 | 9.488 | 11.143 | 11.668 | 13.277 | 14.86 | 16.924 | 18.467 |
| 5 | 0.412 | 0.831 | 7.289 | 9.236 | 11.07 | 12.833 | 13.388 | 15.086 | 16.75 | 18.907 | 20.515 |
| 6 | 0.676 | 1.237 | 8.558 | 10.645 | 12.592 | 14.449 | 15.033 | 16.812 | 18.548 | 20.791 | 22.458 |
| 7 | 0.989 | 1.69 | 9.803 | 12.017 | 14.067 | 16.013 | 16.622 | 18.475 | 20.278 | 22.601 | 24.322 |
| 8 | 1.344 | 2.18 | 11.03 | 13.362 | 15.507 | 17.535 | 18.168 | 20.09 | 21.955 | 24.352 | 26.124 |
| 9 | 1.735 | 2.7 | 12.242 | 14.684 | 16.919 | 19.023 | 19.679 | 21.666 | 23.589 | 26.056 | 27.877 |
| 10 | 2.156 | 3.247 | 13.442 | 15.987 | 18.307 | 20.483 | 21.161 | 23.209 | 25.188 | 27.722 | 29.588 |

Since the calculated test statistic (0.864) is substantially less than the critical value (5.991), we fail to reject the null hypothesis. This evidence suggests that there is no statistically significant association between gender and political party preference in the sampled population.

## Chi-Square Test for Goodness of Fit

The **Chi-Square Goodness of Fit Test** is specifically employed to determine if the observed frequency distribution of a single categorical variable aligns with a predefined, hypothesized theoretical distribution. The null hypothesis for this test asserts that the observed data follows the specified distribution.

**Example Scenario:** Consider a shop owner who claims their weekend customer traffic is distributed as follows: 30% on Friday, 50% on Saturday, and 20% on Sunday. An independent researcher conducts an independent observation, counting 91 customers on Friday, 104 on Saturday, and 65 on Sunday. The researcher decides to test the owner's claim using a level of significance ($alpha$) of 0.10.

After calculating the expected frequencies based on the owner's claim and comparing them to the observed data, the computed test statistic ($chi^2$) for this Goodness of Fit test is 10.616. We now turn to the Chi-Square distribution table to find the critical boundary for the rejection region.

For the Goodness of Fit test, the degrees of freedom are calculated as the number of categories (outcomes) minus one: $df = (text{Number of Outcomes}) - 1$. In this scenario, there are three outcomes (Friday, Saturday, Sunday), yielding $df = 3 - 1 = 2$. Pairing $df=2$ with the specified $alpha=0.10$ in the Chi-Square table reveals the critical value to be **4.605**.

| | P | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 0.995 | 0.975 | 0.2 | 0.1 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.002 | 0.001 |
| 1 | .0004 | .00016 | 1.642 | 2.706 | 3.841 | 5.024 | 5.412 | 6.635 | 7.879 | 9.55 | 10.828 |
| 2 | 0.01 | 0.0506 | 3.219 | 4.605 | 5.991 | 7.378 | 7.824 | 9.21 | 10.597 | 12.429 | 13.816 |
| 3 | 0.0717 | 0.216 | 4.642 | 6.251 | 7.815 | 9.348 | 9.837 | 11.345 | 12.838 | 14.796 | 16.266 |
| 4 | 0.207 | 0.484 | 5.989 | 7.779 | 9.488 | 11.143 | 11.668 | 13.277 | 14.86 | 16.924 | 18.467 |
| 5 | 0.412 | 0.831 | 7.289 | 9.236 | 11.07 | 12.833 | 13.388 | 15.086 | 16.75 | 18.907 | 20.515 |
| 6 | 0.676 | 1.237 | 8.558 | 10.645 | 12.592 | 14.449 | 15.033 | 16.812 | 18.548 | 20.791 | 22.458 |
| 7 | 0.989 | 1.69 | 9.803 | 12.017 | 14.067 | 16.013 | 16.622 | 18.475 | 20.278 | 22.601 | 24.322 |
| 8 | 1.344 | 2.18 | 11.03 | 13.362 | 15.507 | 17.535 | 18.168 | 20.09 | 21.955 | 24.352 | 26.124 |
| 9 | 1.735 | 2.7 | 12.242 | 14.684 | 16.919 | 19.023 | 19.679 | 21.666 | 23.589 | 26.056 | 27.877 |
| 10 | 2.156 | 3.247 | 13.442 | 15.987 | 18.307 | 20.483 | 21.161 | 23.209 | 25.188 | 27.722 | 29.588 |

Since the calculated test statistic (10.616) is significantly larger than the critical value (4.605), we are compelled to reject the null hypothesis. This provides robust statistical evidence that the true distribution of customers visiting the shop on weekends is not consistent with the owner's claim of 30%, 50%, and 20%.

## Chi-Square Test for Homogeneity

The **chi-square test for homogeneity** is employed to formally compare the distribution of a categorical variable across two or more distinct populations or groups. The test investigates whether the proportions of outcomes are the same (homogeneous) across all groups. This test is structurally very similar to the Test for Independence, using the same degrees of freedom formula, but addresses a different research question about populations rather than association between variables.

**Example:** A sports facility introduces two new basketball training programs (Program 1 and Program 2) alongside their Current Program, aiming to improve player success on a shooting test. Players are randomly divided among the three programs (172 to Program 1, 173 to Program 2, and 215 to the Current Program). The facility wants to determine if the proportion of players passing the test is homogeneous (the same) across the three programs, setting the level of significance at 0.05. The results of the shooting test are presented in the following table:

| | Program 1 | Program 2 | Current Program | Total |
|---|---|---|---|---|
| # Passed | 112 | 94 | 130 | 336 |
| # Failed | 60 | 79 | 85 | 224 |
| Total | 172 | 173 | 215 | 560 |

Upon calculation, the test statistic ($chi^2$) for this comparison is found to be 4.208. We must now locate the critical value on the distribution table to complete the hypothesis test.

Similar to the Test for Independence, the degrees of freedom are calculated using the dimensions of the contingency table: $df = (text{Rows}-1) times (text{Columns}-1)$. Given a 2x3 table (Pass/Fail $times$ Program 1/2/Current), $df = (2-1) times (3-1) = 2$. Using $df=2$ and the $alpha=0.05$ level of significance, the Chi-Square distribution table provides a critical value of **5.991**.

| | P | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DF | 0.995 | 0.975 | 0.2 | 0.1 | 0.05 | 0.025 | 0.02 | 0.01 | 0.005 | 0.002 | 0.001 |
| 1 | .0004 | .00016 | 1.642 | 2.706 | 3.841 | 5.024 | 5.412 | 6.635 | 7.879 | 9.55 | 10.828 |
| 2 | 0.01 | 0.0506 | 3.219 | 4.605 | 5.991 | 7.378 | 7.824 | 9.21 | 10.597 | 12.429 | 13.816 |
| 3 | 0.0717 | 0.216 | 4.642 | 6.251 | 7.815 | 9.348 | 9.837 | 11.345 | 12.838 | 14.796 | 16.266 |
| 4 | 0.207 | 0.484 | 5.989 | 7.779 | 9.488 | 11.143 | 11.668 | 13.277 | 14.86 | 16.924 | 18.467 |
| 5 | 0.412 | 0.831 | 7.289 | 9.236 | 11.07 | 12.833 | 13.388 | 15.086 | 16.75 | 18.907 | 20.515 |
| 6 | 0.676 | 1.237 | 8.558 | 10.645 | 12.592 | 14.449 | 15.033 | 16.812 | 18.548 | 20.791 | 22.458 |
| 7 | 0.989 | 1.69 | 9.803 | 12.017 | 14.067 | 16.013 | 16.622 | 18.475 | 20.278 | 22.601 | 24.322 |
| 8 | 1.344 | 2.18 | 11.03 | 13.362 | 15.507 | 17.535 | 18.168 | 20.09 | 21.955 | 24.352 | 26.124 |
| 9 | 1.735 | 2.7 | 12.242 | 14.684 | 16.919 | 19.023 | 19.679 | 21.666 | 23.589 | 26.056 | 27.877 |
| 10 | 2.156 | 3.247 | 13.442 | 15.987 | 18.307 | 20.483 | 21.161 | 23.209 | 25.188 | 27.722 | 29.588 |

Since the calculated test statistic (4.208) is smaller than the critical value (5.991), the result falls within the acceptance region. We therefore fail to reject the null hypothesis. The statistical conclusion is that there is insufficient evidence to claim that the three training programs result in different proportions of players passing the shooting test; the pass rates are considered statistically homogeneous.