

chi square practice problems with answers

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Chi Square Practice Problems with Answers: A Complete Guide

Statistical thinking is essential for researchers, data scientists, and anyone who wants to make sense of real world data. Among the many tools in the statistician's toolbox, the **chi square test** is one of the most widely used. It helps you answer questions such as: "Is the distribution of a categorical variable what we expect?" or "Are two categorical variables independent of one another?"

This article is designed to give you a thorough, practical understanding of chi square tests. We'll walk through the theory, show step by step calculations, and then dive into a set of carefully crafted practice problems with full answers. By the end, you'll be comfortable applying chi square tests in real scenarios, interpreting results, and explaining your findings to a non technical audience.

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What Is the Chi Square Test?

The chi square test is a non parametric statistical test that compares observed frequencies of categorical data to expected frequencies under a particular hypothesis. It's especially useful when you have discrete data that can be categorized into groups, such as "male" vs. "female" or "success" vs. "failure."

At its core, the test evaluates whether any observed deviation from expected counts is likely due to random chance or whether it indicates a real effect. The test statistic, often denoted as χ^2 (chi square), follows a chi square distribution with a known number of degrees of freedom (df). By comparing the computed χ^2 value to a critical value from chi square tables (or by calculating a p value), you can decide whether to reject the null hypothesis.

When to Use the Chi Square Test

The chi square test is appropriate in two main situations:

1. Chi Square Goodness of Fit – When you want to test whether a single categorical variable follows a hypothesized distribution. For example, checking if dice rolls are uniformly distributed.
2. Chi Square Test of Independence – When you have two categorical variables and want to examine whether they are related. For example, assessing whether gender and voting preference are independent.

In both cases, the data should be counts of occurrences in each category. The test is not suitable for continuous

data unless it is first discretized into categories.

Types of Chi Square Tests

Let's explore the two main flavors of the chi square test in more detail.

Chi Square Goodness of Fit

Use this test when you have one categorical variable and a hypothesized distribution. The null hypothesis (H_0) states that the observed frequencies match the expected frequencies derived from the hypothesized distribution.

Chi Square Test of Independence

Use this test when you have two categorical variables and want to see if they are independent. The data is arranged in a contingency table. The null hypothesis (H_0) claims that the row and column variables are independent, meaning the distribution of one variable is the same across all levels of the other variable.

Key Concepts & Terminology

- Observed Frequency (O) – The actual count in each category from your data.
- Expected Frequency (E) – The count you would expect under the null hypothesis.
- Chi Square Statistic ($\chi^2 = \sum \frac{(O - E)^2}{E}$) across all categories.
- Degrees of Freedom (df) – For goodness of fit: $df = k - 1$, where k is the number of categories. For independence: $df = (r - 1)(c - 1)$, where r and c are the number of rows and columns.
- p Value – The probability of observing a chi square statistic as extreme or more extreme than the one computed, assuming H_0 is true.
- Significance Level (α) – The threshold for rejecting H_0 , commonly set at 0.05.

Step by Step Guide to Calculating Chi Square

Below is a generic workflow you can follow for both goodness of fit and independence tests.

1. State the Hypotheses

H_0 : Observed frequencies match expected frequencies (goodness of fit) or variables are independent (independence).

2. H_a : Observed frequencies differ from expected or variables are related.

- For goodness of fit, create a single list of observed counts.
- For independence, build a contingency table with row and column totals.
- Goodness of fit: Multiply the total sample size by the hypothesized probability for each category.
- Independence: Use the formula $E_{ij} = (\text{Row Total}_i \times \text{Column Total}_j) / \text{Grand Total}$.
- Expected count in each cell should be at least 5 for the chi square approximation to be valid. If not, consider combining categories or using Fisher's exact test.
- Use $\chi^2 = \sum \frac{(O - E)^2}{E}$ across all categories or cells.
- Goodness of fit: $df = k - 1$.
- Independence: $df = (r - 1)(c - 1)$.
- Either consult chi square tables or use software (R, Python, Excel) to compute the p value.
- If $p < \alpha$; $\hat{A} \&V\grave{V}7B$, $\hat{a}$

- If $p > \alpha$; fail to reject H_0 .
- Explain what the findings mean in the context of your research question.

Chi Square Practice Problems with Answers

Below are ten practice problems that cover both the goodness of fit and independence tests. Each problem includes a detailed solution. Feel free to try each one on your own before checking the answer.

Problem 1 – Goodness of Fit: Fair Dice

A die is rolled 120 times. The observed counts for each face are:

- 1: 20
- 2: 18
- 3: 22
- 4: 15
- 5: 25
- 6: 20

Test at the 0.05 significance level whether the die is fair.

Answer:

1. H_0 : The die is fair (each face probability = $1/6$).
2. Expected count for each face = $120 \times 1/6 = 20$.
3. Compute χ^2

For face 1: $(20 - 20)^2 / 20 = 0$

4. Face 2: $(18 - 20)^2 / 20 = 0.2$

5. Face 3: $(22 - 20)^2 / 20 = 0.2$

6. Face 4: $(15 - 20)^2 / 20 = 1.25$

7. Face 5: $(25 - 20)^2 / 20 = 1.25$

8. Face 6: $(20 - 20)^2 / 20 = 0$

Problem 2 – Independence: Gender & Voting Preference

A survey of 200 voters records their gender and voting preference (Democrat, Republican, Independent). The data:

- Male: D = 60, R = 30, I = 20
- Female: D = 50, R = 40, I = 10

Test at $\alpha = 0.05$ whether voting preference are independent.

Answer:

1. H_0 : Gender and voting preference are independent.
2. Compute row totals: Male = 110, Female = 100, Total = 200.
3. Column totals: D = 110, R = 70, I = 30.
4. Expected counts:

Male D: $(110 \times 110) / 200 = 60.5$

5. Male R: $(110 \times 70) / 200 = 38.5$

6. Male I: $(110 \times 30) / 200 = 16.5$

7. Female D: $(100 \times 110) / 200 = 55$

8. Female R: $(100 \times 70) / 200 = 35$

9. Female I: $(100 \times 30) / 200 = 15$

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