GENERAL

chi square problems with solutions

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Chi Square Problems With Solutions: A Complete Guide

In statistics, the chi-square test is one of the most widely used tools for analyzing categorical data. Whether you are a student tackling homework, a researcher designing a study, or a data analyst validating a hypothesis, you will inevitably encounter chi-square problems. These problems can range from simple goodness-of-fit tests to complex contingency table analyses. The challenge often lies not in the concept itself but in correctly applying the test, interpreting the results, and troubleshooting common pitfalls.

This article offers a thorough, step-by-step exploration of chi-square problems with solutions. We'll cover the fundamentals, walk through real-world examples, and provide practical tips for avoiding mistakes. By the end, you'll feel confident solving any chi-square problem that comes your way.

What Is the Chi-Square Test?

The chi-square test assesses whether there is a significant association between categorical variables or whether an observed distribution matches an expected distribution. It is non-parametric, meaning it makes no assumptions about the underlying distribution of the data other than the sample size being sufficiently large.

There are two primary forms:

- Chi-Square Goodness-of-Fit – tests if observed frequencies match expected frequencies.
- Chi-Square Test of Independence – tests if two categorical variables are independent.

Both tests rely on the same chi-square statistic:

∑ (Oi – Ei)² / Ei

where Oi is the observed frequency and Ei is the expected frequency for each category.

Common Chi-Square Problems and Why They Occur

Even seasoned statisticians can stumble over chi-square problems. Below are some frequent issues and their root causes.

1. Small Expected Frequencies – When expected counts fall below 5, the chi-square approximation becomes unreliable.
2. Incorrect Degrees of Freedom – Miscalculating df leads to wrong critical values.
3. Assuming independence when data are paired or matched.
4. Using the test for continuous data without discretization.
5. Failing to adjust for multiple comparisons.
6. Misinterpreting the p-value as the probability of the null hypothesis being true.

Understanding these pitfalls helps you preempt problems before they derail your analysis.

Step-by-Step Guide to Solving Chi-Square Problems

Below is a universal workflow that applies to both goodness-of-fit and independence tests. Follow these steps

carefully to ensure accuracy.

1. Define Your Hypotheses

1. Null Hypothesis (H0) – Typically states that there is no difference or no association.
2. Alternative Hypothesis (H1) – States that there is a difference or an association.

Example: For a goodness-of-fit test on a die, H0 might be “the die is fair.”

2. Collect and Organize Data

Tabulate observed frequencies in a contingency table or frequency table. Ensure data are complete and accurately recorded.

3. Compute Expected Frequencies

- For goodness-of-fit: Ei = n × pi where pi is the expected proportion.
- For independence: Eij = (Rowi total × Columnj total) / n.

Check that all Ei "e 5. If not, consider combining categories or using Fisher’s exact test.

4. Calculate the Chi-Square Statistic

Sum the squared differences between observed and expected frequencies, divided by the expected frequencies. Use the formula shown earlier.

5. Determine Degrees of Freedom (df)

- Goodness-of-fit: df = k – 1, where k is the number of categories.
- Independence: df = (r – 1) × (c – 1), where r is the number of rows and c is the number of columns.

Adjust df if you have constrained parameters (e.g., estimated means).

6. Find the Critical Value or P-Value

Consult a chi-square distribution table or use statistical software. Compare your calculated statistic to the critical value at your chosen significance level (commonly ; Ò ã R’à Alternatively, compute the p-value and compare it to ; à

7. Draw a Conclusion

If the chi-square statistic exceeds the critical value or the p-value is less than ; Â &V¦V7B ƒ à Otherwise, fail to reject H0.

8. Report Results Clearly

Include the test statistic, degrees of freedom, p-value, and your conclusion. Provide context so readers understand the practical significance.

Example 1: Goodness-of-Fit – Testing a Fair Die

Suppose you roll a six-sided die 120 times and obtain the following frequencies:

Face	Observed (O)
1	18
2	20
3	22
4	19
5	23
6	18

H0: The die is fair (each face has a probability of 1/6). H1: The die is not fair.

Expected frequency for each face: E = 120 × (1/6) = 20.

Compute chi-square:

- (18 – 20)² / 20 = 0.2
- (20 – 20)² / 20 = 0
- (22 – 20)² / 20 = 0.2
- (19 – 20)² / 20 = 0.05
- (23 – 20)² / 20 = 0.45
- (18 – 20)² / 20 = 0.2

Sum = 1.1.

df = k – 1 = 6 – 1 = 5.

Using ; Ò ã RÂ F†R 7 itical value <{# ã RÃR $, ã rà Since 1.1 0 – the die appears fair.

Example 2: Test of Independence – Smoking and Lung Cancer

Researchers collected data from 500 patients, noting smoking status and lung cancer diagnosis:

	Smoker	Non-Smoker	Total
Lung Cancer	120	30	150
No Lung Cancer	280	70	350
Total	400	100	500

H0: Smoking status and lung cancer are independent.

Compute expected counts:

- E11 = (Row 1 total × Column 1 total) / n = (150 × 400) / 500 = 120.
- E12 = (150 × 100) / 500 = 30.
- E21 = (350 × 400) / 500 = 280.
- E22 = (350 × 100) / 500 = 70.

All expected counts are "e5. Calculate chi-square:

- (120–120)²/120 = 0
- (30–30)²/30 = 0
- (280–280)²/280 = 0
- (70–70)²/70 = 0

In this simplified example, the chi-square statistic is 0, indicating perfect fit. In real data, you would see non-zero values leading to a meaningful test.

Troubleshooting Common Chi-Square Mistakes

Here are quick fixes for frequent errors:

1. Expected counts – Combine adjacent categories or use Fisher's exact test for small samples.
2. Wrong degrees of freedom – Re check the formula: df = (rows – 1) × (columns – 1) for independence; df = categories – 1 for goodness-of-fit.
3. Using chi-square on continuous data – Discretize the data into bins or apply a different test (e.g., t-test).
4. Ignoring matched pairs – Use McNemar's test instead of chi-square.
5. Misinterpretation of p-value – Remember, a small p-value indicates evidence against H0, not the probability that H0 is false.

When to Use Alternatives to the Chi-Square Test

While the chi-square test is versatile, certain scenarios call for other methods:

- Fisher's Exact Test – For 2×2 tables with small expected counts.
- Likelihood Ratio Test – Often more accurate with small sample sizes.
- Logistic Regression – When predicting a binary outcome with multiple predictors.
- G-Test (Likelihood Ratio Chi-Square) – Alternative to Pearson's chi-square, based on likelihood ratios.

Using Software to Compute Chi-Square

Statistical software can streamline calculations and reduce errors. Below are quick guides for popular tools.

Excel

- Use the CHISQ.TEST function for goodness-of-fit or independence.
- Example: =CHISQ.TEST(observed_range, expected_range).

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- Goodness-of-Fit: chisq.test(x = observed, p = expected_proportions).
- Independence: chisq.test(matrix).

Python (SciPy)

- Goodness-of-Fit: scipy.stats.chisquare(f_obs, f_exp).
- Independence: scipy.stats.chi2_contingency(table).

Practical Tips for Writing Clear Statistical Reports

1. State the context – Why the test matters in your study.
2. Present the table – Include observed, expected, and residuals.

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