Detailed Limitations of the Chi-Square Test of Independence

# 1. Requires a Large Sample Size

The chi-square test requires a sufficiently large sample size to produce reliable results. If the expected frequency in any cell is less than 5, the test's validity is compromised. This is because the approximation to the chi-square distribution is poor with small samples, leading to increased risk of Type I or Type II errors. In cases with small sample sizes, Fisher’s Exact Test is preferred.

# 2. Only Applicable to Categorical Data

The chi-square test can only be applied to categorical data (nominal or ordinal). It cannot be used directly with continuous data unless the data is first categorized. This transformation can lead to information loss and introduce bias due to arbitrary binning.

# 3. Does Not Indicate Strength or Direction of Relationship

While the chi-square test indicates whether a statistically significant association exists between two variables, it does not reveal the strength or direction of the relationship. To evaluate the strength, metrics like Cramér’s V or the Phi coefficient should be used.

# 4. Assumes Independence of Observations

One of the assumptions of the chi-square test is that each observation must be independent. If data includes repeated measures from the same individuals or is grouped (e.g., students from the same school), this assumption is violated, rendering the test invalid.

