

CHI-SQUARE TEST

* Definition

- * Chi- square test is the test of significance.
- * It was first of all used by **Karl Pearson** in the year 1900.
- * Chi-square test is a useful measure of comparing experimentally obtained result with those expected theoretically and based on the hypothesis.
- * It is denoted by the Gr. sign- χ^2
- * Following is the formula.

$$\chi^2 = \sum \frac{(\textit{Observed} - \textit{Expected})^2}{\textit{Expected}}$$

- * It is a mathematical expression, representing the ratio between experimentally obtained result (O) and the theoretically expected result (E) based on certain hypothesis. It uses data in the form of frequencies (i.e., the number of occurrence of an event).
- * Chi-square test is calculated by dividing the square of the overall deviation in the observed and expected frequencies by the expected frequency.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

O = the frequencies observed

E = the frequencies expected

Σ = the 'sum of'

- * If there is no difference between actual and observed frequencies, the value of chi-square is zero.
- * If there is a difference between observed and expected frequencies, then the value of chi-square would be more than zero.
- * But the difference in the observed frequencies may also be due to sampling fluctuations and it should be ignored in drawing inference.

* Degree of Freedom

* In test, while comparing the calculated value of χ^2 with the table value, we have to calculate the degree of freedom. The degree of freedom is calculated from the no. of classes. Therefore, the no. of degrees of freedom in a χ^2 test is equal to the no. of classes minus one.

*** If there are two classes, three classes, and four classes, the degree of freedom would be 2-1, 3-1, and 4-1, respectively. In a contingency table, the degree of freedom is calculated in a different manner:**

$$\text{d.f.} = (r-1) (c-1)$$

where- r = number of row in a table,

c = number of column in a table.

*** Thus in a 2×2 contingency table, the degree of freedom is $(2-1) (2-1) = 1$. Similarly, in a 3×3 contingency table, the number of degree of freedom is $(3-1) (3-1) = 4$. Likewise in 3×4 contingency table the degree of freedom is $(3-1) (4-1) = 6$, and so on.**

* Contingency Table

- * The term *contingency table* was first used by Karl Pearson.
- * A contingency table is a type of table in a matrix format that displays the (multivariate) frequency distribution of the variables. They are heavily used in survey research, business intelligence, engineering and scientific research. They provide a basic picture of the interrelation between two variables and can help find interactions between them.

- * **The value of χ^2 depends on the no. of classes or in other words on the number of degrees of freedom (d. f.) and the critical level of probability.**
- * **2×2 table when there are only two sample, each divided into classes and a 2×2 contingency table is prepared. It is also known as **four fold** or **four cell** table.**

2 rows × 2 columns

	Column 1	Column 2	ROW Total
ROW 1	+	+	RT 1
ROW 2	+	+	RT 2
Column Total	CT 1	CT 2	

$$\begin{aligned}\text{Degree of freedom} &= (r-1) (c-1) \\ &= (2-1) (2-1) \\ &= 1 \times 1 \\ &= 1\end{aligned}$$

* Determination of Chi-square test-

* Following steps are required to calculate the value of chi-square.

1. Identify the problem
2. Make a contingency table and note the observed frequency (O) in each class of one event, row wise i.e. horizontally and then the numbers in each group of the other event, column wise i.e. vertically.
3. Set up the Null hypothesis (H_0); According to Null hypothesis, no association exists between attributes. This needs setting up of alternative hypothesis (H_A). It assumes that an association exists between the attributes.
4. Calculate the expected frequencies (E).
5. Find the difference between observed and Expected frequency in each cell (O-E).
6. Calculate the chi-square value applying the formula. The value ranges from zero to Infinite.

* Solved Example-

Two varieties of snapdragons, one with red flower and other with white flowers were crossed. The result obtained in F_2 generation are: 22 red, 52 pink, and 23 white flower plants. Now it is desired to ascertain these figures show that segregation occurs in the simple Mendelian ratio of 1:2:1.

* Solution-

Null hypothesis- H_0 : The genes carrying red color and white color characters are segregating in simple Mendelian ratio of 1:2:1

* Expected frequencies:

$$\text{Red} = \frac{1}{4} \times 97 = 24.25$$

$$\text{Pink} = \frac{2}{4} \times 97 = 48.50$$

$$\text{White} = \frac{1}{4} \times 97 = 24.25$$

	Red	Pink	White	Total
Observed frequency (O)	22	52	23	97
Expected frequency (E)	24.25	48.50	24.25	97
Deviation (O-E)	-2.25	3.50	-1.25	

$$\chi^2 = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

$$= (-2.25)^2 / 24.25 + (3.50)^2 / 48.50 + (-1.25)^2 / 24.25$$

$$= \frac{5.06}{24.25} + \frac{12.25}{48.50} + \frac{1.56}{24.25}$$

$$= 0.21 + 0.25 + 0.06$$

$$= 0.53$$

Conclusion –

The calculated Chi-square value (.53) is less than the tabulated chi-square value (5.99) at 5% level of probability for 2 d. f. The hypothesis is, therefore, in agreement with the recorded facts.