The Chi-Square Test

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Infographic

The Chi-Square Test

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

$$df = c = (N_{rows} - 1) * (N_{columns} - 1)$$

How to Use it?

O represents the observed data values and E represents the expected value of the data point. DF finds the degrees of freedom.

How to Interpret and Present Results

Karl Pearson vs. Yates Chi-Square Test
Difference of 0.5 in the numerator of the formula above

Goodness of Fit Test → Does the sample follow a distribution?

Independence Test → Are the variables of interest related?

Homogeneity test → Are the proportions between groups the same or different? (Franke, Ho, & Christie, 2012).

References

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The University of Utah Department of Sociology. (n.d.). The Chi-Square Test For Independence. SOC.Utah. Retrieved from https://soc.utah.edu/sociology3112/chi-square.php#:~:text=The%20Limitations%20of%20the%20Chi-Square%20Test%20There%20are,trivial%20relationships%20can%20appear%20to%20be%20statistically%20significant.

When is it Used?

This test is used to examine relationships between variables, determine the statistical significance of these relationships, and therefore answer research questions.

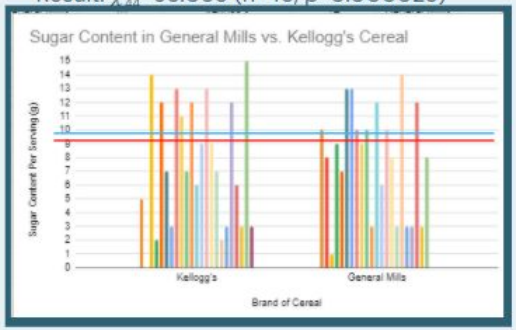
- estimates how well an observed distribution of data matches the expected distribution
- produces **p-values** that indicate if results are significant
- cannot determine causal effect

Example

A data set of common cereals from Kellogg's and General Mills was taken along with sugar content per serving. This was compared with an expected value of the average sugar content in cold cereals of 9.2 grams.

With an **expected value** of 9.2, an **observed value** (χ) of 9.6, and 44 **degrees of freedom**, the calculated **p-value** was 0.000023. This p-value indicates statistical significance.

Result: χ^2_{44}=93.065 (n=45, p=0.000023)



Background

- What is the Chi-Square Test and why is it needed?
  - Examines connections among categorical variables
  - Relationships between variables → answer research questions
  - Produces p-values → statistical significance (Statistics Solutions Staff, 2020)

- When should the test be used?
  - Estimates how well observed distribution of data matches expected distribution
  - p-value indicates significance of test results, but degrees of freedom and alpha value are needed (University of Utah, n.d.)
  - Large sample size → relationships appear more statistically significant
  - Cannot determine causal effect (Surveygizmo Staff, 2018)

Presenting the Test in a Paper or Poster

- Karl Pearson vs. Yates chi-square test
  - Difference of 0.5 in numerator of below formula
- Goodness of Fit test → is the sample different from a specified distribution?
- Independence test → are the variables of interest related?
- Homogeneity test → are the proportions between groups the same or different?
- (Franke, Ho, & Christie, 2012).

$$\chi_c^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

$$df = c = (N_{rows} - 1) * (N_{columns} - 1)$$

Journal Article Interpretation

	Sample (n = 134)	Video-based training (n = 68)	Instructor-based training (n = 66)	p value
Age (years, mean ± *SD*)	25.15 ± 3.27	25.05 ± 3.33	25.25 ± 3.22	0.723
Males (n, %)	58 (43%)	31 (46%)	27 (41%)	0.585
Medical students (n, %)	106 (79%)	54 (79%)	52 (79%)	0.929
Nursing students (n, %)	28 (21%)	14 (21%)	14 (21%)	
Students demonstrating PPV competency (n, %)	3 (2%)	3 (4%)	0	0.379
OSCE score (mean ± *SD*) (max. 26 points)	3.87 ± 4.97	3.86 ± 4.73	3.87 ± 5.25	0.990
OSCE > 70% of total score (n, %)	7 (5%)	3 (4%)	4 (6%)	0.900

OSCE Objective Structured Clinical Examination.

Table 1. Baseline Objective Structured Clinical Exam (OSCE) Breakdown and Scores (Szyld, E. G. et al. (2021). Self-directed video versus instructor-based neonatal resuscitation training: A randomized controlled blinded non-inferiority multicenter international study. *Journal of Perinatology*, 1–7. https://doi.org/10.1038/s41372-021-00941-x).

- Chi-Square Test used → p values obtained
- Confidence level = 95%
- p-values > 0.05 → cannot reject null hypothesis
- No statistically significant relationship between video-based training group and instructor-based training group

Sample Data Set

- Observed Values = actual values on data table (Kaggle Staff, n.d.)
- Expected Values = average sugar in family cereal = 9.2 g (EWG Staff, 2014)
- Result: χ^2_{44}=93.065 (n=45, p=.000023)
  - df = 44 = (45-1)*(2-1)

Name	Manufacturer	Type	Observed Sugars (g)	Expected Sugar (g)	Observed - Expected	(Observed - Expected)^2	(Observed - Expected)^2/Expected
All-Bran	Kellogg's	Cold	5	9.2	-4.2	17.64	1.917391304
All-Bran with Extra Fiber	Kellogg's	Cold	0	9.2	-9.2	84.64	9.2
Apple Cinnamon Cheerios	General Mills	Cold	10	9.2	0.8	0.64	0.06956521739
Apple Jacks	Kellogg's	Cold	14	9.2	4.8	23.04	2.504347826
Basic 4	General Mills	Cold	8	9.2	-1.2	1.44	0.1565217391
Cheerios	General Mills	Cold	1	9.2	-8.2	67.24	7.308695652
Cinnamon Toast Crunch	General Mills	Cold	9	9.2	-0.2	0.04	0.004347826087
Clusters	General Mills	Cold	7	9.2	-2.2	4.84	0.5260869565
Cocoa Puffs	General Mills	Cold	13	9.2	3.8	14.44	1.569565217
Corn Flakes	Kellogg's	Cold	2	9.2	-7.2	51.84	5.634782609
Corn Pops	Kellogg's	Cold	12	9.2	2.8	7.84	0.852173913
Count Chocula	General Mills	Cold	13	9.2	3.8	14.44	1.569565217
Cracklin' Oat Bran	Kellogg's	Cold	7	9.2	-2.2	4.84	0.5260869565
Crispix	Kellogg's	Cold	3	9.2	-6.2	38.44	4.17826087
Crispy Wheat & Raisins	General Mills	Cold	10	9.2	0.8	0.64	0.06956521739
Froot Loops	Kellogg's	Cold	13	9.2	3.8	14.44	1.569565217
Frosted Flakes	Kellogg's	Cold	11	9.2	1.8	3.24	0.352173913
Frosted Mini-Wheats	Kellogg's	Cold	7	9.2	-2.2	4.84	0.5260869565
Fruitful Bran	Kellogg's	Cold	12	9.2	2.8	7.84	0.852173913
Golden Grahams	General Mills	Cold	9	9.2	-0.2	0.04	0.004347826087
Honey Nut Cheerios	General Mills	Cold	10	9.2	0.8	0.64	0.06956521739
Just Right Crunchy Nuggets	Kellogg's	Cold	6	9.2	-3.2	10.24	1.113043478
Just Right Fruit & Nut	Kellogg's	Cold	9	9.2	-0.2	0.04	0.004347826087
Kix	General Mills	Cold	3	9.2	-6.2	38.44	4.17826087
Lucky Charms	General Mills	Cold	12	9.2	2.8	7.84	0.852173913
Mueslix Crispy Blend	Kellogg's	Cold	13	9.2	3.8	14.44	1.569565217
Multi-Grain Cheerios	General Mills	Cold	6	9.2	-3.2	10.24	1.113043478
Nut&Honey Crunch	Kellogg's	Cold	9	9.2	-0.2	0.04	0.004347826087
Nutri-Grain Almond-Raisin	Kellogg's	Cold	7	9.2	-2.2	4.84	0.5260869565
Nutri-grain Wheat	Kellogg's	Cold	2	9.2	-7.2	51.84	5.634782609
Oatmeal Raisin Crisp	General Mills	Cold	10	9.2	0.8	0.64	0.06956521739
Product 19	Kellogg's	Cold	3	9.2	-6.2	38.44	4.17826087
Raisin Bran	Kellogg's	Cold	12	9.2	2.8	7.84	0.852173913
Raisin Nut Bran	General Mills	Cold	8	9.2	-1.2	1.44	0.1565217391
Raisin Squares	Kellogg's	Cold	6	9.2	-3.2	10.24	1.113043478
Rice Krispies	Kellogg's	Cold	3	9.2	-6.2	38.44	4.17826087
Smacks	Kellogg's	Cold	15	9.2	5.8	33.64	3.656521739
Special K	Kellogg's	Cold	3	9.2	-6.2	38.44	4.17826087
Total Corn Flakes	General Mills	Cold	3	9.2	-6.2	38.44	4.17826087
Total Raisin Bran	General Mills	Cold	14	9.2	4.8	23.04	2.504347826
Total Whole Grain	General Mills	Cold	3	9.2	-6.2	38.44	4.17826087
Triples	General Mills	Cold	3	9.2	-6.2	38.44	4.17826087
Trix	General Mills	Cold	12	9.2	2.8	7.84	0.852173913
Wheaties	General Mills	Cold	3	9.2	-6.2	38.44	4.17826087
Wheaties Honey Gold	General Mills	Cold	8	9.2	-1.2	1.44	0.1565217391
Chi Value							9.647031533
Chi Squared							93.06521739

Table 2. A Data Table on the sugar content of cereals with the Chi-Square Analysis applied (Kaggle Staff. (n.d.). *80 Cereals*. Kaggle. Retrieved from https://kaggle.com/crawford/80-cereals).

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Thanks for listening!

Are there any questions?