

11.8: Test of Independence (3 of 3)

Learning Objectives

- Conduct a chi-square test of independence. Interpret the conclusion in context.

On this page, we practice the chi-square test for independence in its entirety and learn how to use statistical software to conduct this test. We also investigate the effect of sample size on the chi-square test statistic.

Try It

A Real Court Case

In the early 1970s, a young man challenged an Oklahoma state law that prohibited the sale of 3.2% beer to males under age 21 but allowed its sale to females in the same age group. The case (*Craig v. Boren*, 429 U.S. 190, 1976) was ultimately heard by the U.S. Supreme Court. The state of Oklahoma argued that the law improved traffic safety. One of the three main pieces of data presented to the court was the result of a “random roadside survey.” This survey gathered information on gender and whether or not the driver had been drinking alcohol in the previous 2 hours. A total of 619 drivers under 21 years of age were included in the survey.

Please [click here to open the simulation](#) for use in the following activity.

<https://assessments.lumenlearning.co...sessments/3809>

<https://assessments.lumenlearning.co...sessments/3810>

<https://assessments.lumenlearning.co...sessments/3811>

<https://assessments.lumenlearning.co...sessments/3812>

<https://assessments.lumenlearning.co...sessments/3813>

<https://assessments.lumenlearning.co...sessments/3814>

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<https://assessments.lumenlearning.co...sessments/3816>

Comment: The Effect of Sample Size on Chi-Square

With other hypothesis tests, we have seen that sample size can affect the P-value and our conclusion. This is also true for chi-square. To illustrate this idea, we multiplied all of the counts in the Oklahoma data by 3.

ORIGINAL DATA			
	Drank Alcohol in Last Two Hours?		
	Yes	No	Totals
Male	77	404	481
Female	16	122	138
Totals	93	526	619

DATA x3			
	Drank Alcohol in Last Two Hours?		
	Yes	No	Totals
Male	231	1212	1443
Female	48	366	414
Totals	279	1578	1857

ORIGINAL DATA			
Conditional Percents			
	Drank Alcohol in Last Two Hours?		
	Yes	No	Totals
Male	77/481 16.0%	404/481 84.0%	481
Female	16/138 11.6%	122/138 88.4%	138
Totals	93	526	619

DATA x3			
Conditional Percents			
	Drank Alcohol in Last Two Hours?		
	Yes	No	Totals
Male	231/1443 16.0%	1212/1443 84.0%	1443
Female	48/414 11.6%	366/414 88.4%	414
Totals	279	1578	1857

Notice that the conditional percentages do not change, so the new “data” shows the same relationship between gender and drinking before driving. The probability that a driver under the age of 21 drinks alcohol before driving is still about 15.0% (279/1857). Males are still more likely to consume alcohol before driving ($231/1443 = 16.0\%$) than are females ($48/414 = 11.6\%$), with the same difference of 4.4% that we saw in the original data.

We used technology to find expected counts and the chi-square test statistic.

ORIGINAL DATA

	Drank Alcohol Yes	Drank Alcohol No	Total
male	77 72.27	404 408.7	481
female	16 20.73	122 117.3	138
Total	93	526	619

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	1.6365641	0.2008

DATA X3

	Drank Alcohol Yes	Drank Alcohol No	Total
male	231 216.8	1212 1226	1443
female	48 62.2	366 351.8	414
Total	279	1578	1857

Chi-Square test:

Statistic	DF	Value	P-value
Chi-square	1	4.9096923	0.0267



Notice that multiplying the observed counts by 3 also triples the expected counts and the chi-square value. This increase in the chi-square value gives a statistically significant P-value of 0.0267, which changes our conclusion. With this larger sample, the evidence is strong enough to reject the null hypothesis. We conclude that gender is associated with drinking alcohol before driving. The variables are dependent for drivers under the age of 21 in Oklahoma. With this sample size, the data provides evidence in support of the Oklahoma law that forbids sale of 3.2% beer to males and permits it to females with the goal of improving traffic safety.

What's the point? We see once again that sample size affects the P-value in a hypothesis test. This means that a small sample may not detect a relationship that exists between two categorical variables in a population. Conversely, a large sample may indicate that a relationship is statistically significant on the basis of differences in observed and expected counts that are not important in a practical sense.

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