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UNIVARIATE STATISTICAL ANALYSIS

TUTORIAL SESSION 9

CHI-SQUARE TEST

Chapter 12

Question 12.7 (page.663) – Twitter user

Question 12.21 (page.677) – Education level and Earnings

Question 12.28 (page.679) – ID and nose views

Age Group	Frequency
18 to 24	7
25 to 34	32
35 to 44	34
45 to 54	60
55 to 64	106
65 and older	136
Total	**375**

Using data from the U.S. Census Bureau (census.gov) for 2014, the age distribution of adults in Texas was 14% between age 18 and 24, 20% between age 25 and 34, 19% between age 35 and 44, 18% between age 45 and 54, 14% between age 55 and 64, and 15% age 65 or older. Is it reasonable to conclude that one or more of the age groups buys a disproportionate share of Texas Lottery tickets? Use a chi-square goodness-of-fit test with $\alpha = 0.05$. (Hint: See Example 12.2.)

12.4 The "Global Automotive 2016 Color Popularity Report" (Axalta Coating Systems, axaltacs.com) included data on the colors for a sample of new cars sold in North America. They reported that 25% of the cars in the sample were white, 21% were black, 16% were gray, 11% were silver, 10% were red, and 17% were some other color. Suppose that these percentages were based on a random sample of 1200 new cars sold in North America. Is there convincing evidence that the proportions of new cars sold are not the same for all six of the color categories?

12.5 A popular urban legend is that more babies than usual are born during certain phases of the lunar cycle, especially near the full moon. The paper "The Effect of the Gravitation of the Moon on Frequency of Births" (*Environmental Health Insights* [2010]: 65–69) classified a random sample of 1007 births at a large hospital in Japan according to lunar phase. In each lunar cycle (27.32 days), the moon moves 360° relative to the earth. To determine lunar phase, the researchers divided the 360° in one lunar cycle into 12 phases of 30°. The sample data are summarized in the accompanying frequency table.

Lunar Phase (degrees)	Number of Births
0–30	90
31–60	81
61–90	76
91–120	87
121–150	90
151–180	76
181–210	94
211–240	79
241–270	76
271–300	80
301–330	93
331–360	85

(continued)

The researchers concluded that the frequency of births is not related to lunar cycle. Carry out a chi-square goodness-of-fit test to determine if the data are consistent with the researchers' claim. Use a significance level of 0.05 for your test.

12.6 The authors of the paper "External Factors and the Incidence of Severe Trauma: Time, Date, Season and Moon" (*Injury* [2014]: S93–S99) classified admissions to hospitals in Germany according to season. They wondered if severe trauma injuries were more common in some seasons than others. Assume that there were 1200 trauma cases in the sample and that the sample is representative of severe trauma injuries in Germany. The data in the accompanying table are consistent with summary quantities given in the paper. Do these data support the theory that the proportion of severe trauma cases is not the same for the four seasons? Test the relevant hypotheses using a significance level of 0.05.

Season				
Winter	Spring	Summer	Fall	Total
228	332	352	288	1,200

12.7 The authors of the paper "Is It Really About Me? Message Content in Social Awareness Streams" (*Computer Supported Cooperative Work 2010*) studied a random sample of 350 Twitter users. For each Twitter user in the sample, the tweets sent during a particular time period were analyzed and the Twitter user was classified into one of the following categories based on the type of messages they usually sent:

Category	Description
IS	Information sharing
OC	Opinions and complaints
RT	Random thoughts
ME	Me now (what I am doing now)
O	Other

The accompanying table gives the observed counts for the five categories (approximate values read from a graph in the paper).

Twitter Type	IS	OC	RT	ME	O
Observed count	51	61	64	101	73

given in the paper are summarized in the accompanying table. Is there convincing evidence that the proportions falling into each of the response categories were not the same for high school students in 2004 and 2014?

	People should be allowed to burn or deface the American flag as a political statement				
	Strongly Agree	Mildly Agree	Mildly Disagree	Strongly Disagree	Don't know
2004	80	80	110	630	100
2014	70	70	110	660	90

12.20 Each person in a representative sample of 445 college students age 18 to 24 was classified according to age and to the response to the following question: "How often have you used a credit card to buy items knowing you wouldn't have money to pay the bill when it arrived?" Possible responses were never, rarely, sometimes, or frequently ("Majoring in Money: How American College Students Manage Their Finances," June 28, 2016, salliemae.newshq.businesswire.com /sites/salliemae.newshq.businesswire.com/files /doc_library/file/SallieMae_MajoringinMoney_2016 .pdf, retrieved May 27, 2017). The responses are summarized in the accompanying table. Do these data provide evidence that there is an association between age group and the response to the question? Test the relevant hypotheses using $\alpha = 0.01$.

	Age 18 to 20	Age 21 to 22	Age 23 to 24
Never	72	62	29
Rarely	36	34	32
Sometimes	30	42	40
Frequently	12	24	32

12.21 The report "Education Pays 2016" (The College Board, trends.collegeboard.org/sites/default /files/education-pays-2016-full-report.pdf, retrieved May 27, 2017) provided information on education level and earnings for a sample of adult Americans who are employed full-time. Data consistent with summary percentages given in the report are summarized in the accompanying table. Suppose this data resulted from a representative sample of 1000 working adults whose highest level of education was a high school diploma, an Associate degree, or a Bachelor's degree. Each person in the sample was classified according to education level (high school diploma, Associate degree, or Bachelor's degree) and yearly income with possible categories of less than \$20,000, \$20,000 to \$39,999, \$40,000 to \$59,999 and \$60,000 or more. Is there evidence of an association between income category and education level? Test the appropriate hypotheses using a 0.05 significance level.

	Less than \$20,000	\$20,000 to \$39,999	\$40,000 to \$59,999	\$60,000 or more
High School Diploma	8	68	106	243
Associate Degree	11	56	56	63
Bachelor's Degree	47	160	101	82

12.22 The report "Consumer Revolving Credit and Debt Over the Life Cycle and Business Cycle" describes a study conducted by the Federal Reserve Bank of Boston (bostonfed.org, October 2015, retrieved May 27, 2017). Data consistent with summary values given in the report are summarized in the accompanying table. Suppose that these data resulted from a random sample of 800 adult Americans age 20 to 39 years old who have at least one credit card. Each person in the sample was classified according to age (with possible categories of 20 to 24 years, 25 to 29 years, 30 to 34 years, and 35 to 39 years). The people in the sample were also classified according to whether or not they pay the full balance on their credit cards each month or sometimes carry over a balance from month to month.

	Pay Full Balance Each Month	Carry Balance from Month to Month
Age 20 to 24 years	75	95
Age 25 to 29 years	74	126
Age 30 to 34 years	75	145
Age 35 to 39 years	67	143

a. To investigate if whether or not people pay their balance in full each month is related to age, which chi-square test (homogeneity or independence) would be the appropriate test? Explain your choice.

b. Carry out an appropriate test to determine if these data provide convincing evidence that whether or not people pay their balance in full each month is related to age.

c. To what population would it be reasonable to generalize the conclusion from the test in Part (b)?

12.23 The paper "Contemporary College Students and Body Piercing" (*Journal of Adolescent Health* [2004]: 58–61) described a survey of 450 undergraduate students at a state university in the southwestern region of the United States. Each student in the sample was classified according to class standing (freshman, sophomore, junior, or senior) and body art category (body piercings only, tattoos only, both tattoos and body piercings, no body art).

believe that it is usually factors outside their control that determines what happens to them. Each student was also classified according to a measure of compulsive buying.

The resulting data are summarized in the accompanying table. Can the researchers conclude that there is an association between locus of control and compulsive buying behavior? Carry out a X^2 test using $\alpha = 0.01$. Assume it is reasonable to regard the sample as representative of college students at midwestern public universities.

		Locus of Control	
		Internal	External
Compulsive Buyer?	Yes	3	14
	No	52	57

12.27 Each person in a large sample of German adolescents was asked to indicate which of 50 popular movies they had seen in the past year. Based on the response, the amount of time (in minutes) of alcohol use contained in the movies the person had watched was estimated. Each person was then classified into one of four groups based on the amount of movie alcohol exposure (groups 1, 2, 3, and 4, with 1 being the lowest exposure and 4 being the highest exposure). Each person was also classified according to school performance. The resulting data is given in the accompanying table (from "Longitudinal Study of Exposure to Entertainment Media and Alcohol Use among German Adolescents," *Pediatrics* [2009]: 989–995).

Assume it is reasonable to regard this sample as a random sample of German adolescents. Is there evidence that there is an association between school performance and movie exposure to alcohol? Carry out a hypothesis test using $\alpha = 0.05$.

		Alcohol Exposure Group			
		1	2	3	4
School Performance	Excellent	110	93	49	65
	Good	328	325	316	295
	Average/ Poor	239	259	312	317

12.28 Can people tell the difference between a female nose and a male nose? This research question was examined in the article "You Can Tell by the Nose: Judging Sex from an Isolated Facial Feature" (*Perception* [1995]: 969–973). Eight Caucasian males and eight Caucasian females posed for nose photos. The article states that none of the volunteers wore nose studs or had prominent nasal hair. Each person placed a black Lycra tube over his or her head in such a way that only the nose protruded through a hole in the material. Photos were then taken from three different angles: front view, three-quarter view, and profile.

These photos were shown to a sample of undergraduate students. Each student in the sample was shown one of the nose photos and asked whether it was a photo of a male or a female. The response was then classified as either correct or incorrect. The accompanying table was constructed using summary values reported in the article.

Is there evidence that the proportion of correct sex identifications differs for the three different nose views?

	View		
Sex ID	Front	Profile	Three-Quarter
Correct	23	26	29
Incorrect	17	14	11

SECTION 12.3 Interpreting and Communicating the Results of Statistical Analyses

Many studies, particularly those in the social sciences, result in categorical data. The questions of interest in such studies often lead to an analysis that involves using a chi-square test.

Communicating the Results of Statistical Analyses

Three different chi-square tests were introduced in this chapter—the goodness-of-fit test, the test for homogeneity, and the test for independence. They are used in different settings and to answer different questions. When summarizing the results of a chi-square test, be sure to indicate which chi-square test was performed. One way to do this is to be clear about how the data were collected and the nature of the hypotheses being tested.

It is also a good idea to include a table of observed and expected counts in addition to reporting the value of the test statistic and the *P*-value. And finally, make sure to give a conclusion in context, and that the conclusion is worded appropriately for the type of test