8.30. (a) For 99% confidence, the margin of error is $2.576\sqrt{\frac{0.39(1-0.39)}{159949}}$ = 0.00314. **(b)** All of these facts suggest possible sources of error; for example, students at 2-year colleges are not represented—nor are students at institutions that do not wish to pay the fee. (Even though the fee is scaled for institution size, larger institutions can more easily absorb it.) None of these potential errors are covered by the margin of error found in part **(a)**, which only accounts for random sampling error. It is really impossible to state how these errors would compare with this margin of error, but one could suppose that a true margin of error would be larger.

8.31. (a) About (0.42)(159,949) = 67,179 students plan to study abroad. **(b)** For 99% confidence, the margin of error is $2.576\sqrt{\frac{0.42(1-0.42)}{159949}}$ = 0.00318. So, 0.42 ± 0.00318 = (0.41682, 0.42318).

8.32. $\hat{p}$ = 1087/1430 = 0.7601, the 95% confidence interval is $0.7601 \pm 1.96\sqrt{\frac{0.7601(1-0.7601)}{1430}}$ = 0.7601 ± 0.0221 = (0.7380, 0.7822).

8.33. $\hat{p}$ = 0.43 and n = 1430, the 95% confidence interval is $0.43 \pm 1.96\sqrt{\frac{0.43(1-0.43)}{1430}}$ = 0.43 ± 0.0257 = (0.4043, 0.4557).

8.34. (a) Narrower. The margin of error is now 0.0168, which is smaller than the previous. This makes the interval (0.4132, 0.4468). **(b)** Wider. The margin of error is now 0.0305, which is larger than the previous. This makes the interval (0.3995, 0.4605).

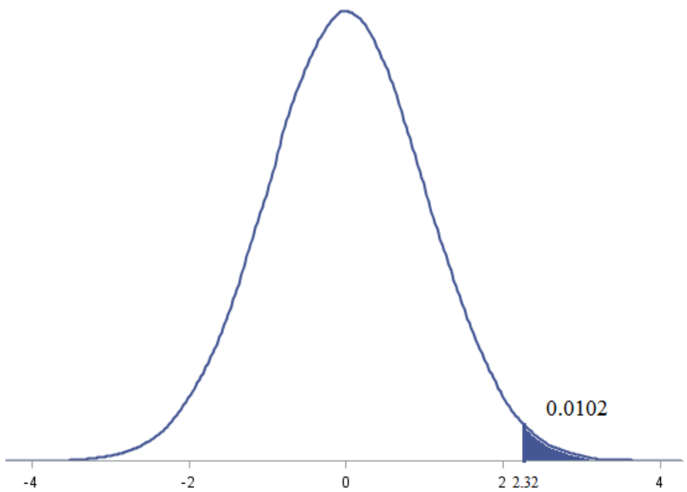
8.35. (a) For 99% confidence, the margin of error is $2.576\sqrt{(0.87)(0.13)/430{,}000}$ = 0.001321. **(b)** One source of error is indicated by the wide variation in response rates: We cannot assume that the statements of respondents represent the opinions of nonrespondents. The effect of the participation fee is more difficult to predict, but one possible impact is on the types of institutions that participate in the survey:

Even though the fee is scaled for institution size, larger institutions can more easily absorb it. These other sources of error are much more significant than the sampling error, which is the only error accounted for in the margin of error from part **(a)**.

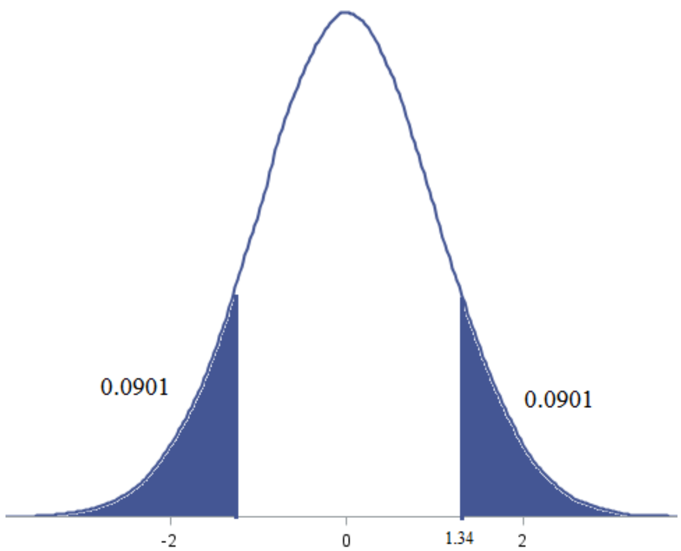
8.36. Both np_0 and $n(1 - p_0)$ need to be at least 10. **(a)** No. $np_0 = 30(0.3) = 9$. **(b)** Yes. **(c)** Yes. **(d)** No. $np_0 = 150(0.04) = 6$.

8.37. (a) $\hat{p} = 390/1191 = 0.3275$. For 95%, the margin of error is $1.96\sqrt{0.3275(1-0.3275)/1191} =$ 0.02665, and the interval is (0.3008, 0.3541). **(b)** Speakers and listeners probably perceive sermon length differently (just as, say, students and lecturers have different perceptions of the length of a class period).

8.38. (a) For those that prefer fresh-brewed coffee: $\hat{p} = 39/60 = 0.35$. H_0: $p = 0.5$, H_a: $p > 0.5$. $z = \dfrac{0.65-0.5}{\sqrt{\dfrac{(0.5)(1-0.5)}{60}}} = 2.32.$ P-value = 0.0102. **(b)** Shown below. **(c)** The result is significant at the 5% level. The result is also practically important, with a large majority, 65%, preferring fresh-brewed coffee.



8.39. (a) $\hat{p} = \dfrac{5067}{10000} = 0.5067.$ $z = \dfrac{0.5067-0.5}{\sqrt{\dfrac{(0.5)(1-0.5)}{10000}}} = 1.34.$ P-value = 0.1802. This is not significant at the 5% level. The data do not provide evidence that the coin is biased. **(b)** The 95% confidence interval is $0.5067 \pm 1.96\sqrt{\dfrac{(0.5067)(1-0.5067)}{10000}} = (0.497, 0.516).$



8.40. With no prior knowledge of p (the proportion of "Yes" responses), take $p^* = 0.5$:

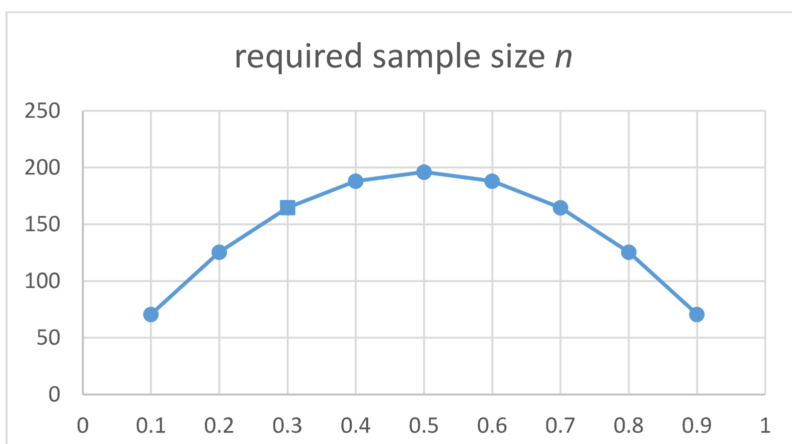
$$n = \left(\frac{1.96}{0.25}\right)^2 \left(\frac{1}{4}\right) = 15.36, \text{ use } n = 16.$$

8.41. $n = \left(\frac{1.96}{0.015}\right)^2 \left(\frac{1}{4}\right) = 4268.4$, use $n = 4269$.

8.42. Using $p^* = 0.20$, $n = \left(\frac{1.96}{0.07}\right)^2 0.2(1-0.2) = 125.44$, use $n = 126$.

8.43. The table below gives the unrounded values; for each case, we would round up to the next integer. To be sure we meet our target margin of error, we should use the largest sample, or $n = 196$.

$\hat{p}$	***n***
0.1	70.56
0.2	125.44
0.3	164.64
0.4	188.16
0.5	196
0.6	188.16
0.7	164.64
0.8	125.44
0.9	70.56



8.44. Using $p^* = 0.25$, $n = \left(\frac{1.96}{0.035}\right)^2 0.25(1-0.25) = 588$.

8.45. Using software, $n = 153$.

8.46. Using software, $n = 19{,}620$.

8.47. Let $D = p_1 - p_2$. $\mu_D = 0.4 - 0.5 = -0.1$, $\sigma_D = \sqrt{\frac{0.4(1-0.4)}{25} + \frac{0.5(1-0.5)}{30}} = 0.1339$.

8.48. (a) Let $D = p_1 - p_2$. $\mu_D = 0.4 - 0.5 = -0.1$, $\sigma_D = \sqrt{\frac{0.4(1-0.4)}{100} + \frac{0.5(1-0.5)}{120}} = 0.0670$. **(b)** With sample sizes four times as large, μ_D is unchanged while σ_D is halved.

8.49. (a) The means are $\mu_{\hat{p}_1} = p_1$ and $\mu_{\hat{p}_2} = p_2$. The standard deviations are $\sigma_{\hat{p}_1} = \sqrt{\frac{p_1(1-p_1)}{n_1}}$

and $\sigma_{\hat{p}_2} = \sqrt{\frac{p_2(1-p_2)}{n_2}}$. **(b)** $\mu_D = \mu_{\hat{p}_1} - \mu_{\hat{p}_2} = p_1 - p_2$. **(c)** $\sigma_D^2 = \sigma_{\hat{p}_1}^2 + \sigma_{\hat{p}_2}^2 = \frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}$.

8.50. $\hat{p}_1 - \hat{p}_2 = -0.1028$. The 95% confidence interval is

$$-0.1028 \pm 1.96\sqrt{\frac{0.4696(1-0.4696)}{115} + \frac{0.5724(1-0.5724)}{145}} = (-0.225, 0.019).$$

8.51. (–0.019, 0.225). We can just reverse the sign of the interval in the previous exercise.

8.52. H_0: $p_W = p_M$, H_a: $p_W \neq p_M$. $\hat{p}_W = \frac{54}{115} = 0.4696$, $\hat{p}_M = \frac{83}{145} = 0.5724$. $\hat{p} = \frac{54+83}{115+145} = 0.5269$.
$z = \frac{0.4696 - 0.5724}{\sqrt{0.5269(1-0.5269)\left(\frac{1}{115} + \frac{1}{145}\right)}} = -1.65$. P-value = 0.0990. The data do not show evidence of a difference between women and men concerning preference of Commercial A.

8.53. With H_0: $p_W = p_M$, H_a: $p_W < p_M$. The test statistic is the same: $z = -1.65$. The P-value = 0.0495, which is significant at the 5% level. The data do show evidence that more men favor Commercial A than women.

8.54. (a) Using p_1 = 0.6 and p_2 = 0.5, we get $m = 1.96\sqrt{\frac{0.6(1-0.6)}{24} + \frac{0.5(1-0.5)}{24}} = 0.28$. Using p_1 = 0.7 and p_2 = 0.5, we get $m = 1.96\sqrt{\frac{0.7(1-0.7)}{24} + \frac{0.5(1-0.5)}{24}} = 0.27$. Using p_1 = 0.8 and p_2 = 0.5, we get $m = 1.96\sqrt{\frac{0.8(1-0.8)}{24} + \frac{0.5(1-0.5)}{24}} = 0.26$. **(b)** Yes. Under all three conditions, the margin of error is much larger than the desired 0.1 as given in **Example 8.17**.

8.55. Using software, we need 686 women and 686 men.

8.56. (a) The population consists of all male customers in a similar environment. $X_1 = 40$, $n_1 = 69$, $X_2 = 130$, $n_2 = 349$. $\hat{p}_1 = 40/69 = 0.5797$, $\hat{p}_2 = 130/349 = 0.3725$; their difference is 0.2072. **(b)** The population is all runners. $X_1 = 9$, $n_1 = 20$, $X_2 = 6$, $n_2 = 20$. $\hat{p}_1 = 9/20 = 0.45$, $\hat{p}_2 = 6/20 = 0.30$; their difference is 0.15.

8.57. (a) This was an experiment; although we cannot assign who visits the establishment, we could randomly assign which type of server they get. There were more than 10 successes and failures in each group, so assuming random assignment, the guidelines are generally met. **(b)** This is an experiment; the runners were randomly assigned; however, there are less than 10 successes in each group. Hence, the guidelines are not met.

8.58. (a) The 95% confidence interval is $0.2072 \pm 1.96\sqrt{\frac{0.5797(1-0.5797)}{69}+\frac{0.3725(1-0.3725)}{349}}$ = (0.0802, 0.3343). With 95% confidence, the percent of male customers tipping a red shirt server is between 8.02% and 33.43% higher than the percent of male customers tipping a different colored shirt server. **(b)** The 95% confidence interval is $0.15 \pm 1.96\sqrt{\frac{0.45(1-0.45)}{20}+\frac{0.30(1-0.30)}{20}}$ = (–0.1464, 0.4464). With 95% confidence, the percent of runners satisfied with the first stretching routine is between 14.64% lower and 44.64% higher than the percent of runners satisfied with the second stretching routine.

8.59. (a) The guidelines are met; the number of successes and failures in each group was at least five. **(b)** The guidelines are met; the number of successes and failures in each group was at least five.

8.60. (a) $H_0: p_1 = p_2$. $H_a: p_1 \neq p_2$. $\hat{p}_1 = \frac{40}{69} = 0.5797, \hat{p}_2 = \frac{130}{349} = 0.3725$. $\hat{p} = \frac{40+130}{69+349} = 0.4067$.

$$z = \frac{0.5797-0.3725}{\sqrt{0.4067(1-0.4067)\left(\frac{1}{69}+\frac{1}{349}\right)}} = 3.20.$$

P-value = 0.0014. The data provide evidence that, for male customers, the percent who tip a red-shirted server is different than the percent who tip a different-colored-shirt server. **(b)** $H_0: p_1 = p_2$. $H_a: p_1 \neq p_2$. $\hat{p}_1 = \frac{9}{20} = 0.45, \hat{p}_2 = \frac{6}{20} = 0.30$. $\hat{p} = \frac{9+6}{20+20} = 0.375$.

$$z = \frac{0.45-0.30}{\sqrt{0.375(1-0.375)\left(\frac{1}{20}+\frac{1}{20}\right)}} = 0.98.$$

P-value = 0.3270. The data do not show a difference in satisfaction between the percent of runners satisfied with each of the two stretching routines.

8.61. (a) RR = (40/69)/(130/349) = 1.56. Males customers are 1.56 times as likely to tip a red-shirted server than a different-colored-shirt server. **(b)** RR = (9/20)/(6/20) = 1.5. A runner is 1.5 times as likely to be satisfied with the first stretching routine than the second stretching routine.

8.62. (a) $\hat{p}_{40+} = \frac{3801}{43,786} = 0.0868$ and $\hat{p}_{<20} = \frac{68}{58,952} = 0.0012$. **(b)** The 99% confidence interval is $0.0868 - 0.0012 \pm 2.576\sqrt{\frac{0.0868(1-0.0868)}{43786}+\frac{0.0012(1-0.0012)}{58952}}$ = (0.0820, 0.0892). **(c)** $H_0: p_1 = p_2$. $H_a: p_1 \neq p_2$. $\hat{p} = \frac{68+3801}{58,952+43,786} = 0.0377$.

$$z = \frac{0.0868-0.0012}{\sqrt{0.0377(1-0.0377)\left(\frac{1}{43786}+\frac{1}{58952}\right)}} = 71.33.$$

P-value ≈ 0.

We have enough evidence to conclude there was an age-group difference in the rejection rate during the Spanish–American War due to bad teeth. **(d)** These are not simple random samples from a larger population, although they fit the guidelines for numbers of "successes" and "failures." While we can say that older recruits were definitely more likely to be rejected due to bad teeth, there are no larger populations to which this result applies.

8.63. (a) Type of college is explanatory; response is whether physical education is required. **(b)** The populations are private and public colleges and universities. **(c)** $X_1 = 101$, $n_1 = 129$, $\hat{p}_1 = 101/129 = 0.7829$. $X_2 = 60$, $n_2 = 225$, $\hat{p}_2 = 60/225 = 0.2667$. **(d)**

$0.7829 - 0.2667 \pm 1.96\sqrt{\frac{0.7829(1-0.7829)}{129} + \frac{0.2667(1-0.2667)}{225}} = (0.4245, 0.6079)$. We note this interval does not contain 0; it appears that public institutions are more likely to require physical education. **(e)** H_0: $p_1 = p_2$. H_a: $p_1 \neq p_2$. $\hat{p} = \frac{60+101}{225+129} = 0.4548$. $z = \frac{0.7829 - 0.2667}{\sqrt{0.4548(1-0.4548)\left(\frac{1}{225}+\frac{1}{129}\right)}} = 9.39$. P-value ≈ 0. **(f)** There were 101 public institutions that require physical education and 18 that do not. There were 60 private institutions that require physical education and 165 that do not. All these counts are greater than 5. We do not know if the samples were SRSs. (g) It appears that public institutions are much more likely to require physical education (by an estimated 42.45% to 60.79%) at 95% confidence.

8.64. (a) The populations are Canadian students in grades 10 and 11 or who (or who do not) stress about their health. **(b)** Let population 1 be those who do stress about their health. $X_1 = 0.299(358) = 107$, $n_1 = 358$, $\hat{p}_1 = 0.299$, $X_2 = 0.208(851) = 177$, $n_2 = 851$, $\hat{p}_2 = 0.208$. **(c)** All counts of exergamers (or not) are more than 10. Were these SRSs? How were the students selected? **(d)** Yes, provided the samples can be viewed as SRSs from the two populations.

8.65. $SE_D = \sqrt{\frac{0.299(1-0.299)}{358} + \frac{0.208(1-0.208)}{851}} = 0.0279$. $(0.299 - 0.208) \pm 1.96(0.0279) = (0.0363, 0.1457)$. Based on these samples, we'd estimate at 95% confidence that among Canadian youth in 10th and 11th grades, between 3.6% and 14.6% more youths who stress about their health are exergamers than those who do not stress about their health.

8.66. H_0: $p_1 = p_2$. H_a: $p_1 \neq p_2$. We have $\hat{p} = \frac{107+177}{358+851} = 0.2349$.
$z = \frac{0.299 - 0.208}{\sqrt{0.2349(1-0.2349)\left(\frac{1}{358}+\frac{1}{851}\right)}} = 3.41$. P-value = 0.0006. We reject the null hypothesis of no difference in exergaming between those who do and do not stress about their health; those who stress about their health (among Canadians in grades 10 and 11) are more likely to be exergamers.

8.67. (a) Table below. The values of X_1 and X_2 are estimated as (0.54)(1063) and (0.89)(1064). **(b)** The estimated difference is $\hat{p}_2 - \hat{p}_1 = 0.35$. **(c)** Large-sample methods should be appropriate because we have large, independent samples from two populations, and we have at least five successes and failures in each sample. **(d)** With $SE_D = 0.01805$, the 95% confidence interval is $0.35 \pm 0.03537 = (0.3146, 0.3854)$. **(e)** The estimated difference is about 35%, and the interval is about 31.5% to 38.5%. **(f)** A possible concern is that adults were surveyed before Christmas, while teens were surveyed before and after Christmas. It might be that some of those teens may have received game consoles as gifts but eventually grew tired of them.

Population	Population proportion	Sample size	Count of successes	Sample proportion
1 (adults)	p_1	1063	574	0.54
2 (teens)	p_2	1064	947	0.89

8.68. H_0: $p_1 = p_2$. H_a: $p_1 \neq p_2$. $\hat{p} = \dfrac{574 + 947}{1063 + 1064} = 0.7151$. $z = \dfrac{0.89 - 0.54}{\sqrt{0.7151(1-0.7151)\left(\dfrac{1}{1063}+\dfrac{1}{1064}\right)}} = 17.88.$

P-value ≈ 0. The difference in gaming on consoles is extremely significant. We have overwhelming evidence that more teens than adults play on consoles.

8.69. (a) Table below. The values of X_1 and X_2 are estimated as (0.73)(1063) and (0.76)(1064). **(b)** The estimated difference is $\hat{p}_2 - \hat{p}_1 = 0.03$. **(c)** Large-sample methods should be appropriate because we have large, independent samples from two populations, and we have at least five successes and failures in each sample. **(d)** With SE_D = 0.01889, the 95% confidence interval is 0.03 ± 0.03702 = (−0.0070, 0.0670). **(e)** The estimated difference is about 3%, and the interval is about −0.7% to 6.7%. **(f)** As previously, a possible concern is that adults were surveyed before Christmas.

Population	Population proportion	Sample size	Count of successes	Sample proportion
1 (adults)	p_1	1063	776	0.73
2 (teens)	p_2	1064	809	0.76

8.70 H_0: $p_1 = p_2$. H_a: $p_1 \neq p_2$. $\hat{p} = \dfrac{776 + 809}{1063 + 1064} = 0.7452$. $z = \dfrac{0.76 - 0.73}{\sqrt{0.7452(1-0.7452)\left(\dfrac{1}{1063}+\dfrac{1}{1064}\right)}} = 1.60.$

P-value = 0.1096. The difference in gaming on computers is not statistically significant. It appears that teens and adults may game on computers similarly.

8.71. No. This procedure requires independent samples from different populations. We have one sample (of teens).

8.72. (a) H_0 should refer to p_1 and p_2 (population proportions) rather than $\hat{p}_1$ and $\hat{p}_2$ (sample proportions). **(b)** Knowing $\hat{p}_1 = \hat{p}_2$ does not tell us that the success counts are equal ($X_1 = X_2$) *unless* the sample sizes are also equal ($n_1 = n_2$). **(c)** Confidence intervals only account for random sampling error.

8.73. (a) Using software: (i) 199, (ii) 294, (iii) 356, (iv) 388, (v) 388, (vi) 356, (vii) 294, (viii) 199. **(b)** As p_1 and p_2 get closer to 0.5, the necessary sample size to achieve the same power gets larger. As p_1 and p_2 get farther from 0.5, the necessary sample size to achieve the same power gets smaller.

8.74. Focusing on those who thought there would be no major increases in gamification by 2020, $\hat{p} = 0.42$. The 95% confidence interval is $0.42 \pm 1.96\sqrt{\dfrac{(0.42)(1-0.42)}{1021}} = (0.3897, 0.4503)$. With 95% confidence, the proportion of people who think that there will be no major increases in gamification by 2020 is between 38.97% and 45.03%. Focusing on those who believed there would be significant advances in the adoption of gamification by 2020, $\hat{p} = 0.53$. The 95% confidence interval is

$0.53 \pm 1.96\sqrt{\frac{(0.53)(1-0.53)}{1021}} = (0.4994, 0.5606)$. With 95% confidence, the proportion of people who believe there will be significant advances in the adoption of gamification by 2020 is between 49.94% and 56.06%. A higher proportion of people think there will be significant adoption of gamification by 2020 than the proportion who think there will be no major increases in gamification.

8.75. (a) $n = 2342$, $X = 1639$. **(b)** $\hat{p} = \frac{1639}{2342} = 0.7$. $SE_{\hat{p}} = \sqrt{\frac{0.7(1-0.7)}{2342}} = 0.0095$. **(c)** The 95% confidence interval is $0.7 \pm 1.96\sqrt{\frac{(0.7)(1-0.7)}{2342}} = (0.681, 0.718)$. With 95% confidence, the proportion of people who get their news from the desktop or laptop is between 68.1% and 71.8%. **(d)** Yes. We have at least 10 successes and failures in the sample.

8.76. The populations are children 5 to 10 years old (population 1) and children 11 to 13 years old (population 2). Let X_i = the number who met the requirement in each population. $X_1 = 861$, $n_1 = 861 + 194 = 1055$. $X_2 = 417$, $n_2 = 417 + 557 = 974$.

8.77. We have large samples from two independent populations (different age groups). $\hat{p}_1 = 861/1055 = 0.8161$, $\hat{p}_2 = 417/974 = 0.4281$. $SE_D = \sqrt{\frac{0.8161(0.1839)}{1055} + \frac{0.4281(0.5719)}{974}} = 0.0198$. The 95% confidence interval for the difference in the proportion of children in these age groups who get enough calcium in their diets is (0.8161 – 0.4281) ± 1.96(0.0198) = (0.3492, 0.4268). Because the interval is entirely above 0, we can conclude that children 5 to 10 years old are much more likely to get adequate calcium in their diets than children 11 to 13 years old.

8.78. $H_0: p_1 = p_2$. $H_a: p_1 \neq p_2$. $\hat{p} = \frac{861+417}{1055+974} = 0.6299$. $z = \frac{0.8161 - 0.4281}{\sqrt{0.6299(1-0.6299)\left(\frac{1}{1055}+\frac{1}{974}\right)}} = 18.08$.

P-value ≈ 0. We have overwhelming evidence that children 5 to 10 years old are more likely to get the calcium required in their diets than children 11 to 13 years old. The test is valid because we have large samples from two independent populations; we'll have to assume these children represent an SRS from their respective age groups.

8.79. Answers will vary. The confidence interval gives more information on the actual size of the difference.

8.80. (a) $\hat{p}$ = 463/975 = 0.4749. SE = 0.01599; the 95% confidence interval is (0.4435, 0.5062). **(b)** Expressed as percents, the confidence interval is 44.35% to 50.62%. **(c)** Multiply the upper and lower limits of the confidence interval by 37,500: about 16,632 to 18,982 students.

8.81. (a) 0.67(1802) = 1207. **(b)** 0.67 ±1.96(0.01108) = (0.6483, 0.6917). **(c)** About 64.8% to 69.2% of all Internet users use Facebook, at 95% confidence.

8.82. (a) 0.16(1802) = 288. **(b)** 0.16 ±1.96(0.0086) = (0.1431, 0.1769). **(c)** About 14.3% to 17.7% of all Internet users use Twitter, at 95% confidence.

8.83. No. Many people use both; there was only one sample, not two independent samples.